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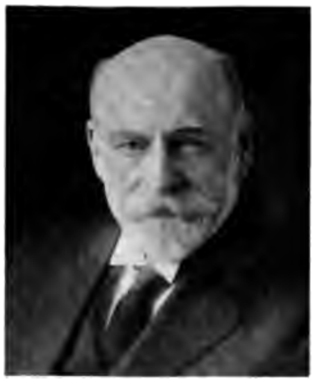

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PLATE I.

DEPARTMENT OF MINES AND AGRICULTURE.

MEMOIRS OF THE GEOLOGICAL SURVEY OF NEW SOUTH WALES.
E. F. PITTMAN, A.R.S.M., UNDER SECRETARY AND GOVERNMENT GEOLOGIST.

GEOLOGY, No. 6.

GEOLOGY AND MINERAL RESOURCES
OF THE
WESTERN COALFIELD;
WITH
MAPS AND SECTIONS.

BY

J. E. CARNE, F.G.S.,
ASSISTANT GOVERNMENT GEOLOGIST.

ISSUED BY DIRECTION OF THE HON. JOHN PERRY, M.P., MINISTER FOR MINES AND AGRICULTURE.

SYDNEY: WILLIAM APPLEGATE GULLICK, GOVERNMENT PRINTER.

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Total area surveyed ... ... 350 square miles.
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[1] Subsequent mining measurements on the Capertee and Wolgan are shown on a later issue on a larger scale, obtainable at the Department of Mines and Agriculture.

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LETTER OF TRANSMITTAL.

Geological Survey Branch,
Department of Mines and Agriculture,
Sydney, 9th December, 1907.

Sir,

I have the honor to submit for publication a Memoir (No. 6 of the Geological Series) on the *Geology and Mineral Resources of the Western Coal-field*, by Mr. J. E. Carne, F.G.S., Assistant Government Geologist.

The mapping and scientific description of the valuable Coal-fields of the State is work of the utmost importance to the mineral industry, and it is of no less interest when regarded from a scientific point of view.

Following upon the recently-issued Memoir on the Geology of the Hunter River Coal Measures, by Professor David, B.A., F.R.S., the present volume will, I feel sure, be welcomed by those interested in coal-mining throughout the State.

Mr. Carne has devoted a great amount of patience and energy to the work, and it is confidently felt that his Memoir will reflect credit both upon the Department and himself.

I have the honour to be,
Sir,
Your obedient servant,
EDWARD F. PITTMAN,
Government Geologist.

The Honourable JOHN PERRY, M.P.,
Minister for Mines and Agriculture.

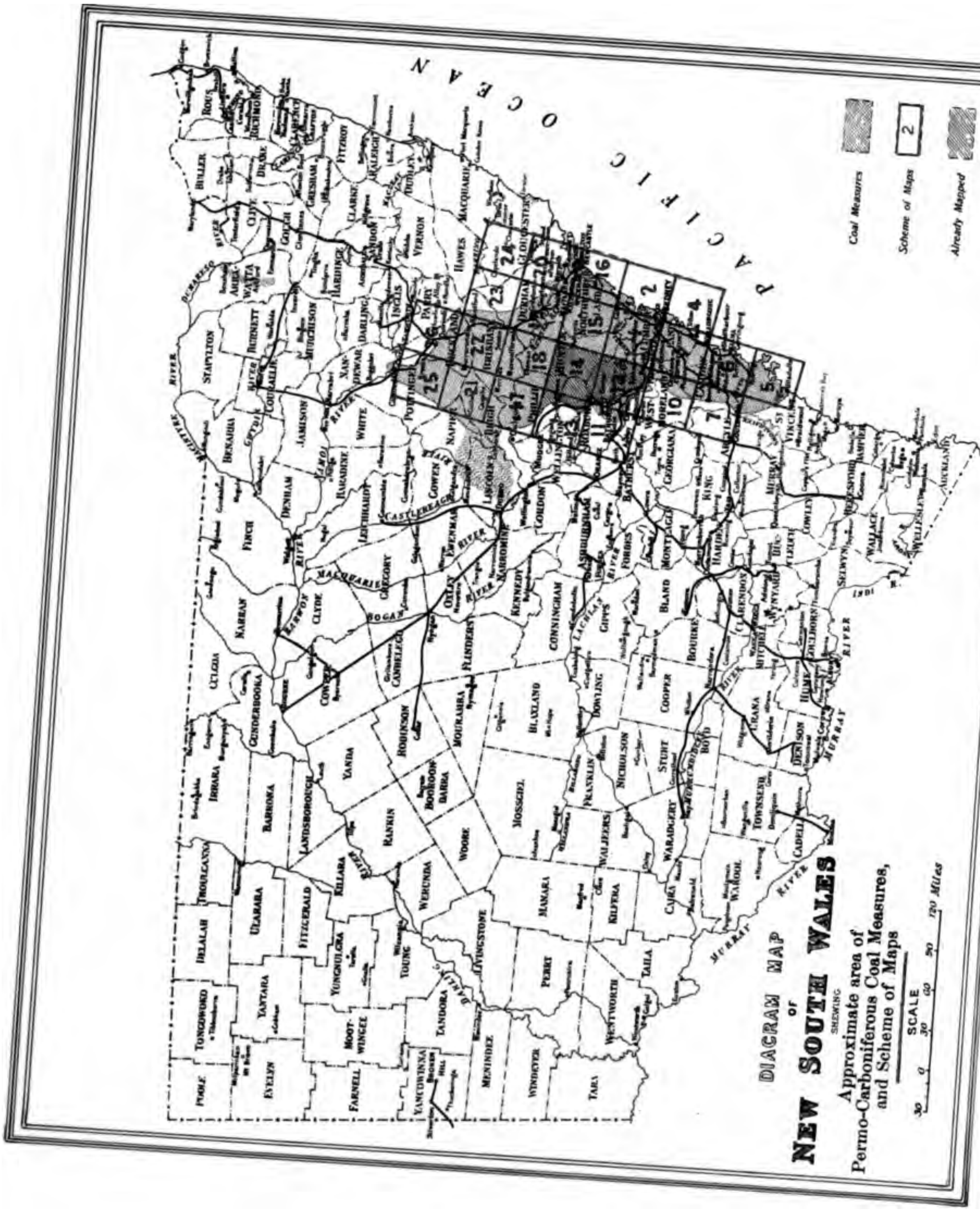

DIAGRAM MAP
OF
NEW SOUTH WALES
SHEWING
Approximate area of
Permo-Carboniferous Coal Measures,
and Scheme of Maps

PHOTO-LITHOGRAPHED BY W. A. GULLICK, GOVERNMENT PRINTER, SYDNEY, N.S.W.

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PART I.

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THE Northern, Southern, and Western Coal-fields form one continuous area,
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This Memoir, with the accompanying maps and sections dealing with the Western Coal-field, is the first instalment of a systematic geological survey of the productive Coal Measures of New South Wales, and the issue, as opportunity offers, of maps on a scale of two miles to an inch.

The estimated area of Permo-Carboniferous coal lands has been approximately divided into equal rectangular spaces containing one thousand two hundred and ninety-six square miles, and consecutively numbered, as on the accompanying diagram, showing relative positions.

Under this scheme the order of mapping can be varied to meet exigencies of discovery or development without disturbing the general plan, and in this uniform series previous surveys of smaller areas on different scales will—with due acknowledgment—be incorporated. These sheets will be accompanied by letterpress.

The magnitude of the task, the inaccessibility, and the fact that the greater portion of the area to be dealt with is practically unsurveyed, render sketch-mapping alone possible, excepting in the more settled areas.

The country, geologically defined on the four maps accompanying this Memoir, embraces the principal parts of Counties Cook and Hunter, and a considerable portion of Roxburgh and Phillip.

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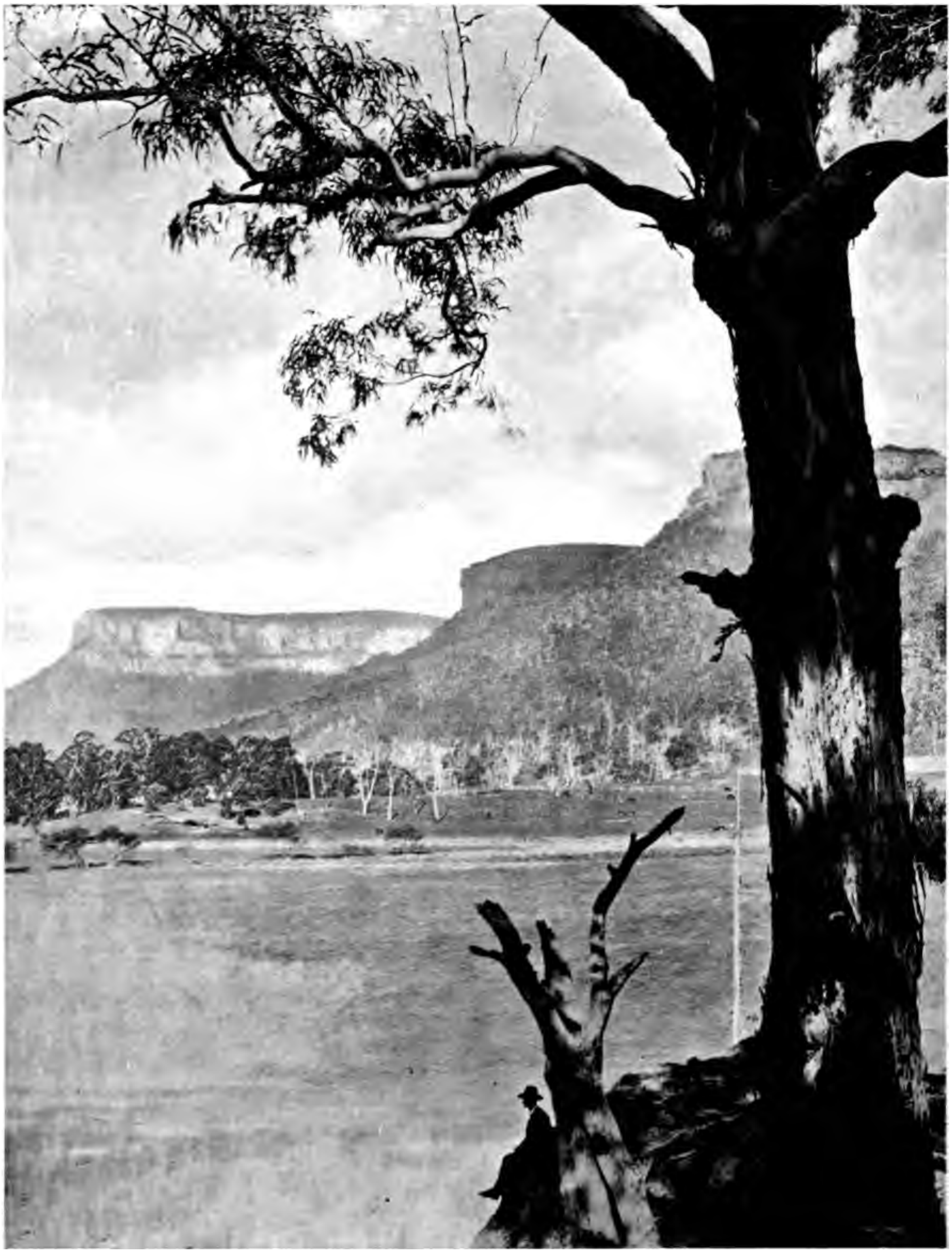
The principal part of what is generally understood as the "Blue Mountains" proper, is embraced in the present maps. Sheet 12 contains the best known portion, that traversed by the Great Western road and railway, along which residential settlement has of late years rapidly increased, altitude, and accessibility to the metropolis, rendering it a desirable summer resort and sanatorium. Heights above sea-level, along the road and railway, range from one thousand seven hundred and twenty-six feet at Linden, to three thousand six hundred and fifty-eight feet at Clarence, a distance of thirty-six miles following the sinuous curves of the line along the water-parting between the Cox and Grose Valleys, or twenty-three direct. Clarence being eighty-eight miles from Sydney and fifty-two from the eastern foot of the Mountains.

Between the stations mentioned greater elevations, adjacent to the railway, have been avoided in its construction. Bald Mount, three thousand eight hundred and forty-eight feet, and Mount Clarence, three thousand eight hundred and fifteen feet, marking the highest trignometrical stations. A height of nearly four thousand feet, however, is reached about two and a half miles north-west, near Portion 52 on Bell's Line.

This sheet also includes the basalt areas of Mounts Wilson, Irvine, Tomah, Cameron, and several inconspicuous outcrops of similar rock, in the most accessible of which fertility and luxuriant flora complete the charm of mountain dwelling.

The Lithgow and Wallerawang, or Western Coal Workings, are also included, as also parts of the Capertee-Wolgan Kerosene Shale Deposits.

Sheet 14 lies immediately north of the former, and includes the Lower Capertee and the remainder of the Wolgan extension of the shale deposit, which is at present attracting considerable attention owing to the introduction of extensive capital for its development.



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THE GULLIES, CAPERTEE VALLEY, SHOWING THE HAWKESBURY SERIES (TRIASSIC) CAPPING THE PERMO-CARBONIFEROUS COAL MEASURES.

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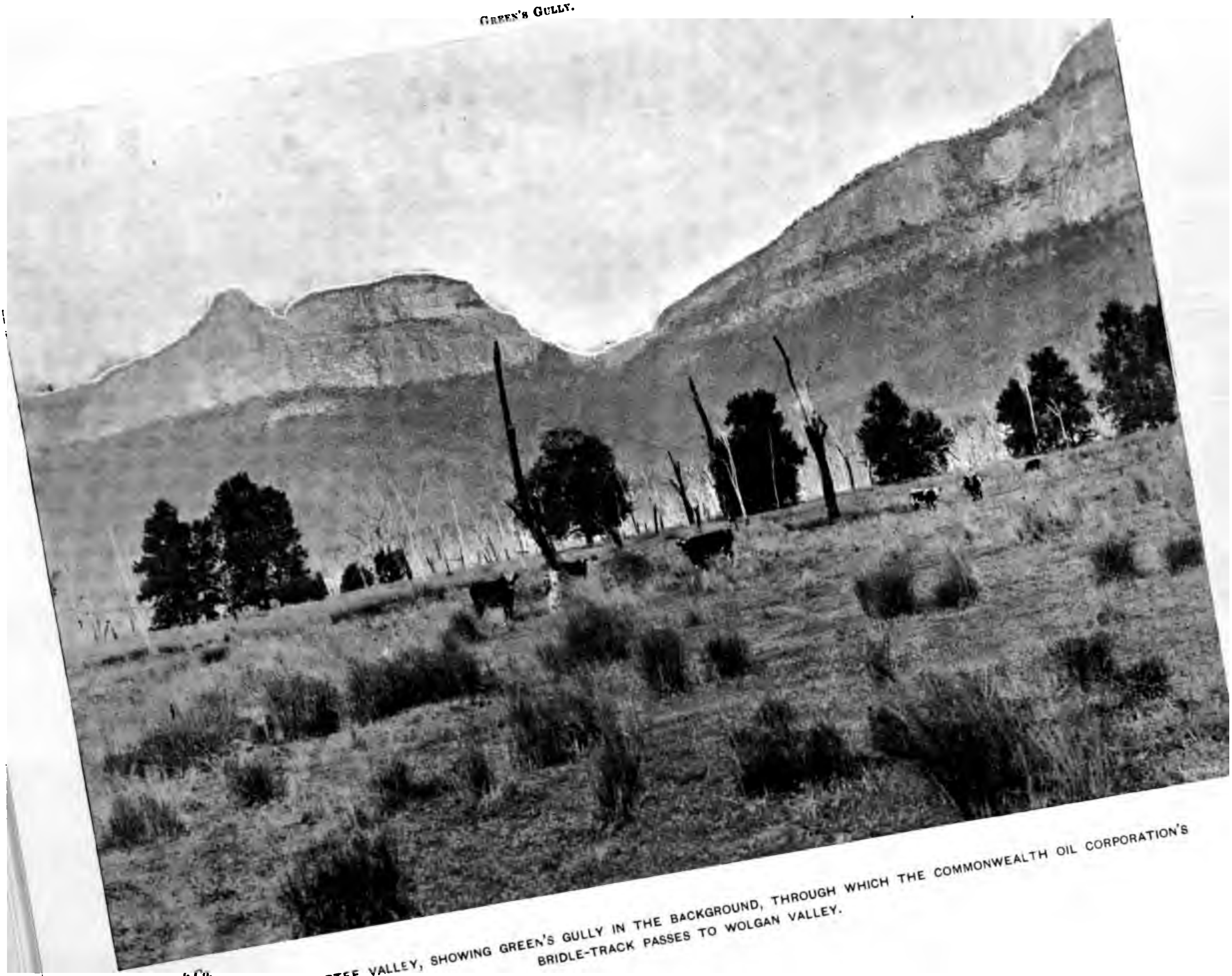

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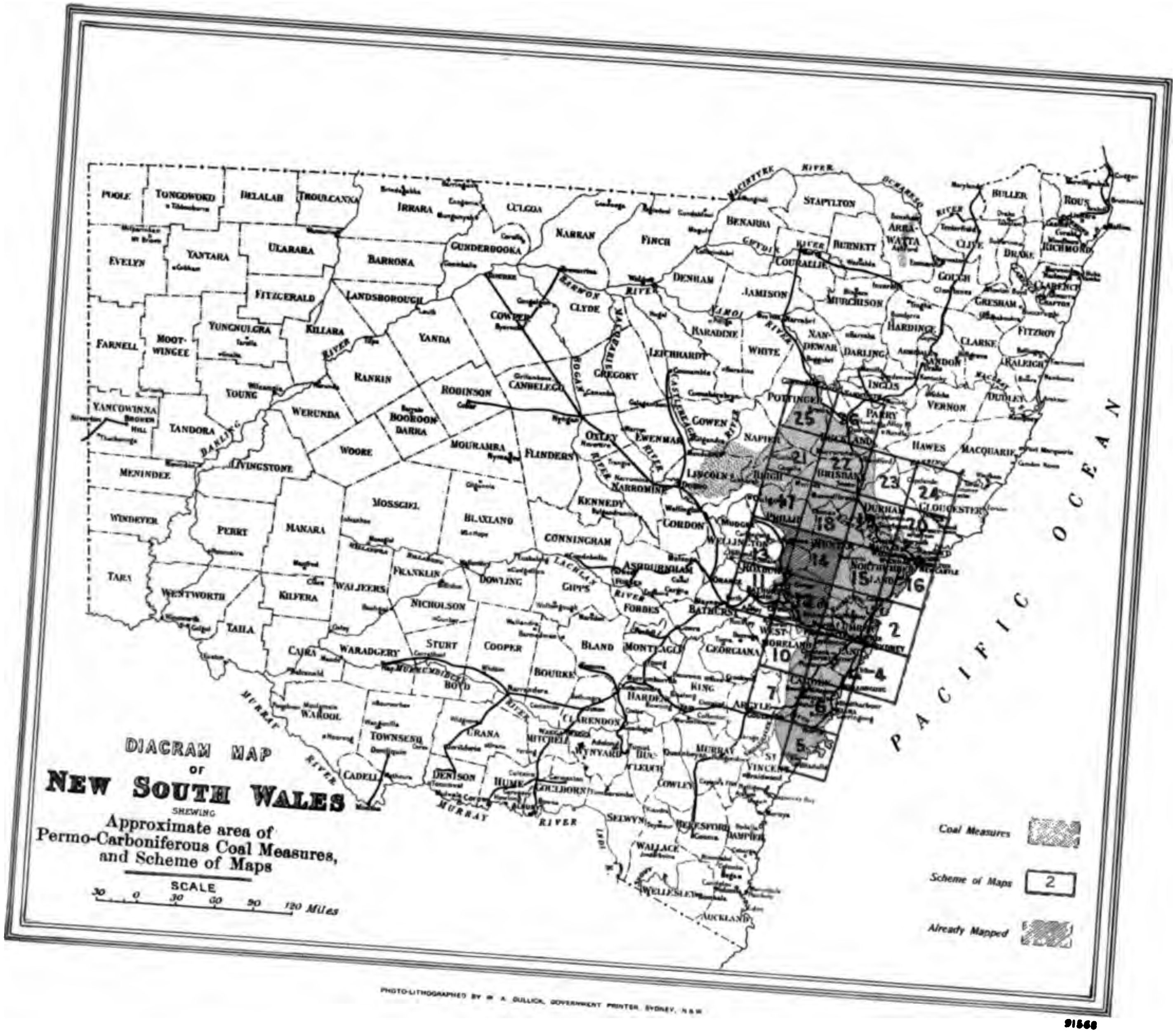

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PLATE III.

GREEN'S GULLY.

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THE GULLIES, CAPERTEE VALLEY, SHOWING GREEN'S GULLY IN THE BACKGROUND, THROUGH WHICH THE COMMONWEALTH OIL CORPORATION'S BRIDLE-TRACK PASSES TO WOLGAN VALLEY.

Satisfactory completion of arrangements for smelting local iron ores at Lithgow, in connection with State contracts for iron supplies, and further extensive development of the kerosene shale export and retorting industry in the district, render the present Memoir opportune, as supplementary to those already issued on Iron Deposits [1] and Kerosene Shale.[2]

The occurrence of abundant limestone within sixteen miles by rail of the seat of the new iron smelting works is an important essential, to say nothing of the splendid cement industry established in connection therewith by the Commonwealth Portland Cement Company, Limited, a description of which is given under the head of Economic Geology (p. 247).

From a study of the natural advantages offered in the way of situation and local resources—such as coal, kerosene shale, limestone, iron ore, brick and fire clays, building stone, &c.—and converging railway communication from the west, it is evident that the Lithgow-Wallerawang district possesses the essential elements for successful progress.

Industrial development in the narrow Lithgow Valley must shortly lead to suburban settlement, for which the undulating country round Bowenfels and Marangaroo, over three thousand feet above sea-level, offers exceptional advantages. If higher altitudes are desired, the Blue Mountains can offer none better than the breezy heights above the Great Zig Zag, or about Mount Clarence, within easy reach by rail.

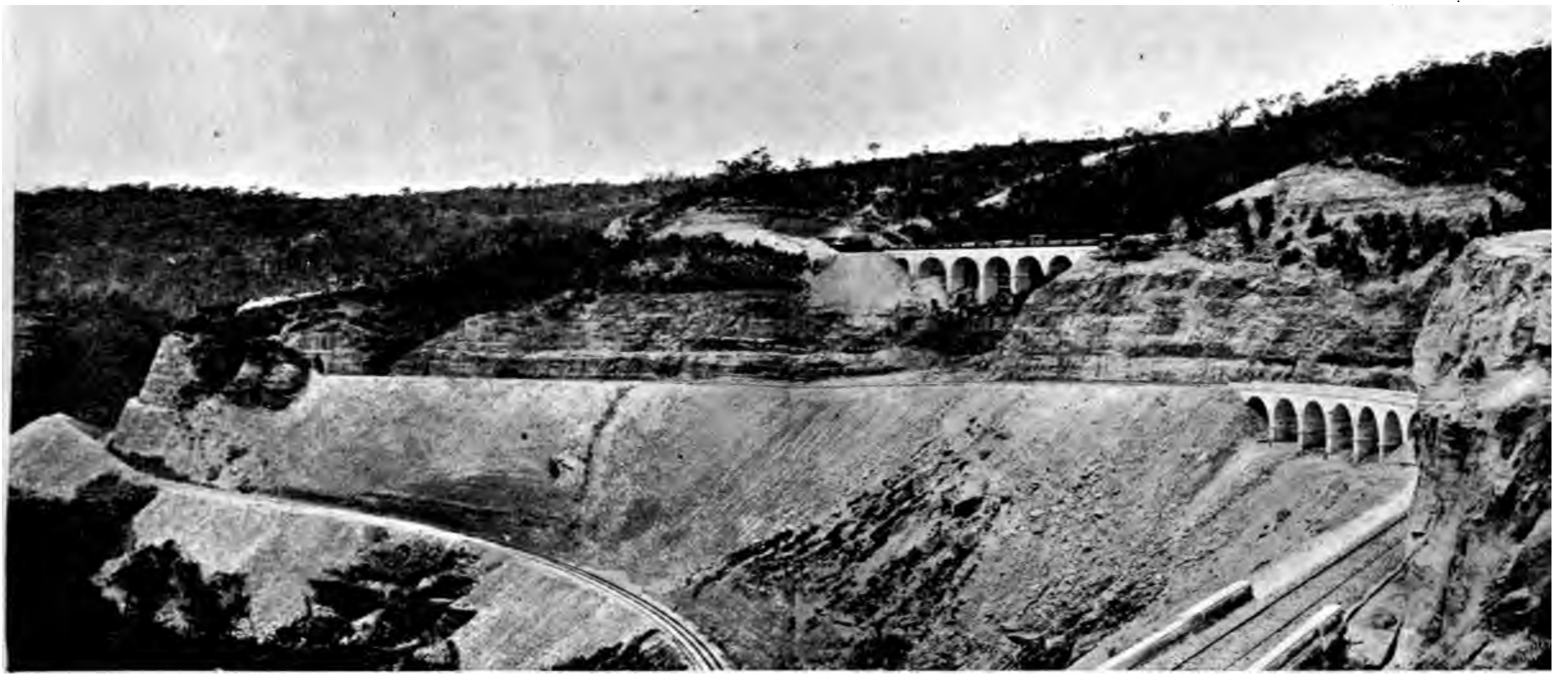
If the iron-smelting venture realises the national aspiration, busy industries will occupy the valley, and comfortable homes the hills.

Unless otherwise specified, the sections of coal-seams shown herein were carefully measured, and the corresponding samples for analysis taken by the Writer from the full working thicknesses, exclusive of bands. The final test samples being secured in the usual way by breaking, mixing, and parting the bulk coal stripped from the faces. The large selected samples were further carefully reduced to powder and mixed in the laboratory before testing.

---

[1] Iron Deposits of N. S. Wales, by J. B. Jaquet.—Memoirs of Geol. Surv. N. S. Wales, No. 2, 1901.

[2] Kerosene Shale Deposits of N. S. Wales, by J. E. Carne.—Memoirs of Geol. Surv. N. S. Wales, No. 3, 1903.



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THE GREAT ZIG ZAG INTO LITHGOW VALLEY.

To Mr. George Anderson, Mr. Henry Deane, M.A., M.I.C.E., and Mr. James Hardie, thanks are due for information and assistance in viewing developments in connection with the above-mentioned Corporation.

To Mr. W. Hall, Manager of the Torbane and Hartley Mines and Works; Mr. J. W. Rock, Mr. M. Zobel, Mr. R. Barber, Mr. H. Valentine, Mr. J. G. Hutton, Mr. J. Palmer, Mr. H. L. Jene, and other members of the Commonwealth Corporation staff, acknowledgment is made for valuable help.

Dr. Scheidel, Managing Director, Commonwealth Portland Cement Company (Ltd.), kindly supplied views of the Company's works and quarries, and Mr. J. Saville, Works Manager, information pertaining thereto.

Cordial thanks are also offered the following gentlemen for information or assistance rendered:—Mr. W. Sandford, Managing Director (W. Sandford, Ltd.); Mr. P. G. Pennymore, F.C.S., Manager, Iron Blast Furnace, Lithgow; Mr. R. H. Bulkeley, Shire Councillor, Wallerawang; Mr. J. H. Gale, Managing Partner, Cooerwull Woollen Mills; Mr. T. Wilton, Managing Director, Lithgow Valley and Hermitage Collieries; Mr. J. Campbell, Mining Manager, Lithgow Valley and Hermitage Collieries; Mr. R. Hay, Manager, Oakey Park Colliery and Coke Works; Mr. J. Durie, Manager, Zig Zag Colliery; Mr. T. Broughall, Manager, Vale of Clwydd Colliery; Mr. J. W. Spooner, Manager, Ironworks Colliery; Mr. G. H. Blakemore, General Manager, Great Cobar (Ltd.); Mr. W. H. Corbould, Managing Director, Lloyd Copper-mining Company (Ltd.); Mr. W. Crawford, Manager, Invincible Colliery, Cullen Bullen; Mr. W. Burns, Manager, Ivanhoe Colliery, Piper's Flat; Mr. J. Fitzgerald, Manager, Irondale Colliery, Piper's Flat; Mr. C. Procter, Manager, Portland Colliery, Piper's Flat; Mr. H. Winchester, Coal-fields Office, Newcastle; Mr. P. Winchester, Cullen Bullen; Mr. J. Edwards, Katoomba.

To Mr. A. C. Barwick, Public School, Putty, the Writer is indebted for valuable assistance in locating numerous volcanic phenomena in the Putty district.

III.—BLUE MOUNTAINS.

Historical and Descriptive.—The term "*Blue*" Mountains was applied to these mountains owing to their most distinctive colour when viewed from a distance, and is employed in Governor Phillip's first account of the settlement on the shores of Port Jackson.

From a point of vantage reached during a short tour inland in 1788, Phillip viewed the bold eastern front of the mountains (abutting against the coastal plain about thirty miles west of the settlement), which for twenty-five years were destined to effectually bar progress into the interior in that direction.

In 1790 Phillip ascended the Hawkesbury River to their foot; a low eminence on the west bank of the stream, named "Richmond Hill"—where Belmont House now stands—marking the limit of exploration.

The northern and southern divisions of the mountain face, severed by the remarkable cleft-like channel of the Grose River, were named "Carmarthen" and "Landsdown" Hills.[1] These names, like others bestowed by right of priority on prominent peaks of the Blue Mountains, have fallen into disuse; the most regrettable being "Mount Banks," the original name of Mount King George.[2]

"Blue Mountains" remains a common name for the elevated plateau region, west of Penrith and Richmond, but the geographic limitations have neither been strictly nor uniformly defined. Physiographic conditions partially determine eastern and western, but northern and southern remain purely arbitrary.

Professor T. W. Edgeworth David, B.A., F.R.S., F.G.S., refers to the usually restricted application of the name to the country between the Hawkesbury River on the east, Lithgow Valley on the west, the Warragamba on the south, and the Colo on the north.[3]

For the purpose of this Memoir, however, it comprehends all the elevated plateau formed by the coterminous Hawkesbury (Triassic) Series, capping the Coal Measures within the accompanying maps. In future issues these bounds will be further extended, both north and south.

The eastern boundary of the Blue Mountains proper terminates at the Nepean or Hawkesbury River, but the plateau series extends to the coast. The western is defined by bold escarpments of the Hawkesbury Series, fronting the eastern falling valleys of the Cox and Wollondilly; thence sweeping round by Bowenfels to Lithgow Valley, whence it extends west and north-west to Ilford, Rylstone, Botobolar, the Goulburn River, and beyond.

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[1] Hist. Records N. S. Wales, 1 (2), p. 133.

[2] See pages 9–10.

[3] Journ. R. Soc. N. S. Wales, 1896, XXX., p. 41.

The abrupt eastern face of the mountains opposite Penrith and Richmond—at the foot of which the Hawkesbury River has a meridianal course between the Warragamba and Colo junctions—has been determined by a monoclinal fold[1] depressing the intervening area between it and the coast several hundred feet. An associated fault, with a maximum displacement due to bending and sheering of about five hundred feet,[2] imparts a somewhat similarly bold face to the western aspect of the fold at Kurrajong Heights. This western depression extends from south of the Grose Valley to Mount Condor on the north; and as far west as Mount Tomah, where there is evidence of an eastern down-fold of about two hundred and fifty feet (*Ibid.*, p. 368).

The Kurrajong anticline forms a bold narrow ridge between the eastern and western curves of the monocline.

The massive Hawkesbury Sandstone constituting the plateau, warped beneath sea-level at Penrith, reappears as coastal cliffs at Sydney; the intervening basin being occupied by the Wianamatta Shales. North of the Colo and south of the Warragamba, the physiographic influence of the monocline disappears in the broadening plateau extending to the Hunter River on the north, and thinning out southerly against older formations.

Sweeping round to the eastward, at right angles to the strike of the fold, the plateau series maintain their characteristic structure eastward to the coast, north and south of the depressed Sydney-Penrith area, reaching in both directions elevations of over fourteen hundred feet above the sea at their base.

Early References.—Captain Paterson first attempted the ascent of the Grose Valley, which nearly intersects the mountains from west to east, and succeeded in reaching a point about ten miles above its junction with the Hawkesbury. To the stream flowing through the valley he gave the name it bears, doubtless in honour of Lieutenant Grose, who superintended the first settlement on the Hawkesbury. To a high western peak in view from Grose Mouth he gave the name of "Harrington Peak." (Probably Mount Hay.)

From "Grose Head"—the south point of the Grose cleft through the plateau front—Governor Bligh viewed the country described in his letter to the Right Honorable W. Wyndham, of the 31st October, 1807,[1] in which he recorded an unfavourable opinion of the possibility of further advance of settlement.

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[1] David, Journ. Roy. Soc. N.S. Wales, 1896, XXX, p. 41.

[2] David, *ibid.*, 1902, XXXVI, pp. 365, 366.

In 1804, George Caley, Botanist, with several assistants, penetrated the mountains as far west as Mount Banks or King George. Starting along the north bank of Grose Valley, he gradually worked north-westerly to the water parting between the Colo and Grose, which he followed to the mountain peak mentioned. Returning along it to its junction with the Kurrajong Range, he crossed the latter somewhere near the present Kurrajong Heights. Along this route A. Bell, of Belmont, afterwards opened the stock route which bears his name, continuing it along the northern bank of the Grose, and over Clarence Ridge to the fall into Lithgow Valley, where the descent from the plateau was made.

Caley prepared a plan of his route, showing the most prominent features, together with outlines and bearings of ranges and hills, viewed from the summit levels of Tomah and Mount Banks. This was attached to Governor King's account of the Colony, apparently addressed to Sir Joseph Banks, dated Sydney, 2nd November, 1805, together with a short extract from Caley's journal. Unfortunately, the latter appears to have been lost, as no other record is known.

Caley's route was shown on Surveyor-General Grimes' Map of New South Wales, published in 1806.[2] But Surveyor-General Mitchell, in his map of 1834—which embraces most of the Blue Mountains topography depicted on recent issues of the Survey Department of the State—entirely overlooked or ignored Caley's undoubted right of nomenclature. The original and present names are here placed in juxtaposition:—

Caley, 1804.	Mitchell, 1834.
Fern Tree Hill	Mount Tomah.
Table Hill	Mount Bell.
Mount Banks	Mount King George.
Haystack	....

As Tomah is stated by Alan Cunningham to have been the aboriginal name,[3] the alteration was appropriate. Table Hill was renamed Mount Bell by Mitchell, in honour of A. Bell, of Belmont, according to Surveyor Govett.[4]

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[1] Hist. Records N. S. Wales, VI, p. 350.

[2] Hist. Records N. S. Wales, VI, 1806-8, p. 310.

[3] Hooker's Journ. of Botany, IV, 1842.

Unpublished Records, Dept. of Lands, N. S. Wales.

It is, however, a matter for regret that Caley's naming of the most prominent and furthest peak reached by him, on the north bank of the Grose, should not have been perpetuated in honour of the great botanist—Sir Joseph Banks—who rendered signal service to the young settlement.[1] More especially as the explorer, writing to the latter on the 10th December, 1804,[2] acquainted him with the fact; adding, "Being the first European to visit these parts, I claim the privilege of giving names to a few places which appear to me the most obvious."

The Writer has given to a hitherto unnamed but prominent basalt-capped peak, intermediate between Mounts Tomah, Banks, and Hay, the early explorer's name, as it marks, approximately, the western limit of his journey in 1804.

It is regrettable that Governor King contented himself with extracts from Caley's journal, instead of giving it *in extenso*. The observations of one who approached his work in the spirit Caley evidenced in his letter to Sir Joseph Banks of the 12th October, 1800, shortly after his arrival in Australia, were assuredly worthy of preservation intact:—"I am extremely well satisfied with the field I have before me. I have already found plenty of new objects in the few miles I have yet travelled. I do not mean to ramble a great way into the country at the first setting out. Every inch of ground I consider as sacred, and not to be trampled over without being noticed."[3]

Governor Macquarie, when traversing the road just completed over the Blue Mountains in 1815, named a small cairn near Linden, "Caley's Repulse;" under the impression that it marked the latter's furthest point. Blaxland had previously—in 1813—attributed it to Bass. It is, however, practically certain that Caley was never on the Mountains south of the Grose.

Under Sir Thomas Mitchell, Surveyor-General, a topographical survey of the plateau and its coastal extension was begun. The principal features of his map, published in London in 1834, are utilised in present issues from the State Survey Department.

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[1] Since the above was written, it is gratifying to record that the Banks Memorial Committee, on the Author's initiative, has obtained official approval for the restoration of the name on the State maps. On sheet 12, accompanying this Memoir, it appears for the first time, as directed—Mount Banks or King George.

[2] Hist. Records, N.S. Wales, I (2), p. 133.

[3] Hist. Records, N.S. Wales, IV (1800–1802), p. 240.

Tomah, viewed from the plateau level at Blackheath or Mount Victoria, across the magnificent valley of the Grose (over two thousand four hundred feet in depth) appear to rise above, though actually beneath, that plane.

In tectonic relationship and inclination, the sandstone summits beneath their basalt crowns, agree with superior levels south and south-westerly. Sections from the Great Western Railway, northerly through Mount Hay, Mount Banks, and Tomah, or north-easterly to the coast, or easterly to Glenbrook monocline, reveal complete stratigraphical sequence and normal inclination.

Certain distinctive strata are represented throughout the plateau series, the stratigraphical relationship and petrological characteristics of which are equally typical of eminences, near the coast or the northern plateau, as of greater elevations on the Blue Mountains proper.

Parallelism and geological identity in the structural arrangement of gently inclined strata, constituting high points on the Blue Mountains and lower ones nearer the coast, indicate synchronous erosion of intervening areas during and subsequent to uplift (excepting that affected by the monocline and fault), and are opposed to the statement that the higher levels of the Blue Mountain plateau are "mesas" *or worn "residuals"* of original independent peneplains—two, three, or four—formed in rotation at sea-level, and successively uplifted and denuded during intermittent and oscillating epeirogenic movements.[1] A statement which has been profoundly, not to say drastically, varied by its author in each of several succeeding issues bearing on the subject.[2]

If the intervening denuded portions were restored, the surface of the Blue Mountain plateau would form a slightly inclined plane consonant with strike and dip of component strata. As Professor W. J. Stephens wrote:—"The general slope of the original surface from the base of those eminences, such as Mount King George, Mount Tomah, and Mount Hay, which have been preserved from denudation by their caps of basalt, down to the eastern escarpment, is, of course, determined for us by the summit levels of the various ridges which remain as watersheds of general drainage."[3]

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[1] E. C. Andrews, Proc. Linn. Soc. N. S. Wales, 1903, XXVIII, Pt. 4, pp. 786-825.

[2] Records Geol. Survey N. S. Wales, 1904, VII, Pt. 4, pp. 281-300. Educational Gazette N. S. Wales, XIII and XIV, 1903-4 Introduction to Physical Geography of N. S. Wales, 1905.

[3] Journ. Roy. Soc. N.S.W., 1832, XVI, p. 103.

Persistent bands of soft shales alternating with massive sandstones, induced comparatively rapid lateral degradation, by "benching" or undercutting, along planes of unstable shales back to vertical joints in overlying sandstones. Alternations of this character exposed by intersecting channels, produced a series of step-like levels with bold marginal escarpments, such as have been mistaken for peneplains.

A glance at the insignificant streams meandering through wide-topped, vertically-scarped valleys, like that of Govett's Leap, shows how small the part they have had in lateral valley extension, and affords some criterion of the rate of widening compared with vertical erosion. Even longitudinal extension is mostly accelerated—as in the case cited—by undercutting. The shallow entering streams fall over precipices of Hawkesbury Sandstone forming semicircular bays at the heads of the valleys.

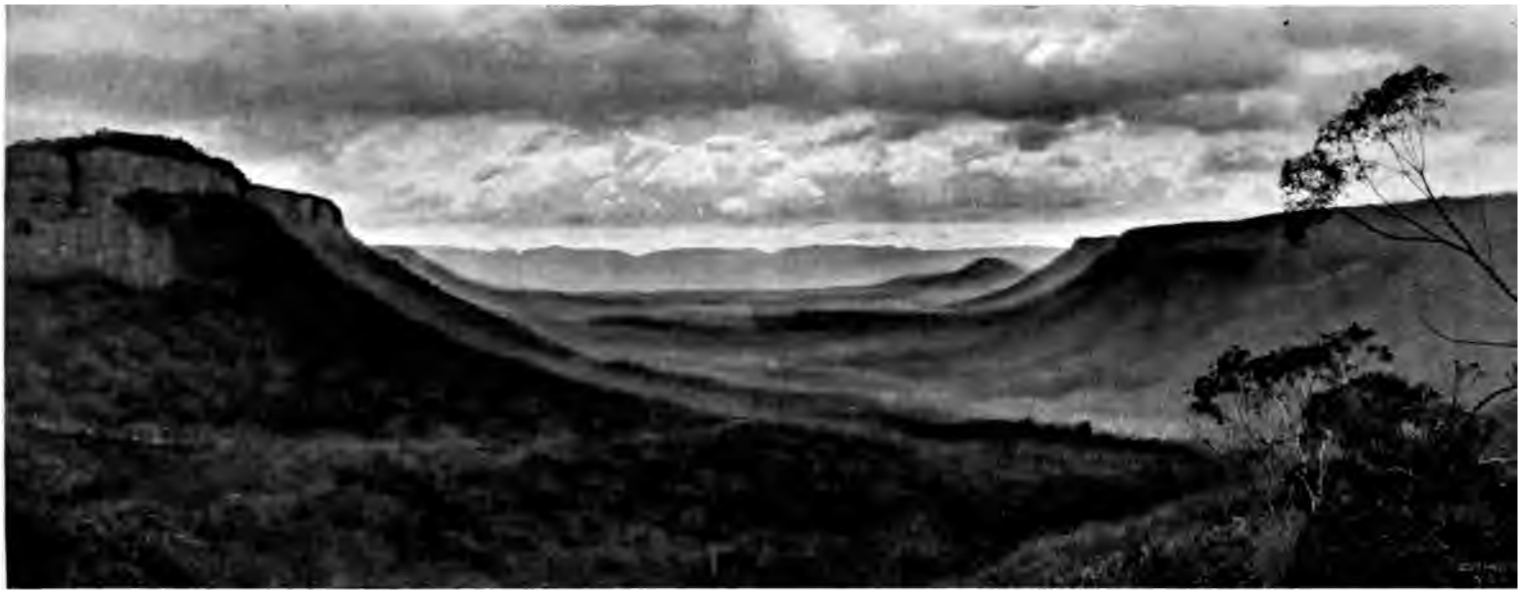
No wide shallow basins or uniform planes of erosion have been achieved. From the crest of the mountains the main water-partings, like those traversed by the Great Western road and railway and Bell's Line, between the Cox, Grose, and Colo Rivers, slope uniformly coastwards, their angles unbroken save by recent denudation or by depression.

From these water-partings lateral spurs extend to the intervening canyons, bearing on their crests peaks—like Hat Hill—partially isolated by convergent stream-heads reducing the divides to low saddles. From these, again, branching spurs are repeated on a diminishing scale.

Between all these—uplands, laterals, branches, and spurs—an intricate drainage system ramifies through deep canyons and narrow ravines, up giant step-like falls, to higher levels with shallower streams reaching the verge of the uplands, revealing in their range the entire plateau structure.

In the whole sphere of stream action and denudation, the most impressive feature is the bluff, wall-like, "benching" induced by geological structure. The perpendicularity of the stupendous jointed sandstone walls of the canyons, which lend such grandeur to Blue Mountain scenery, is constantly maintained by the sapping effect of weathering in intercalated and underlying unstable shales,

PLATE VI.



Kerry & Co.

UPPER PORTION OF WOLGAN VALLEY SHOWING ROAD FROM WALLERAWANG.

The following sketch outline, drawn from photographs by Mr. R. H. Cambage, L.S., shows the amount of denudation suffered by the plateau since the basalt sheet spread over that portion of it, probably in late Tertiary time.

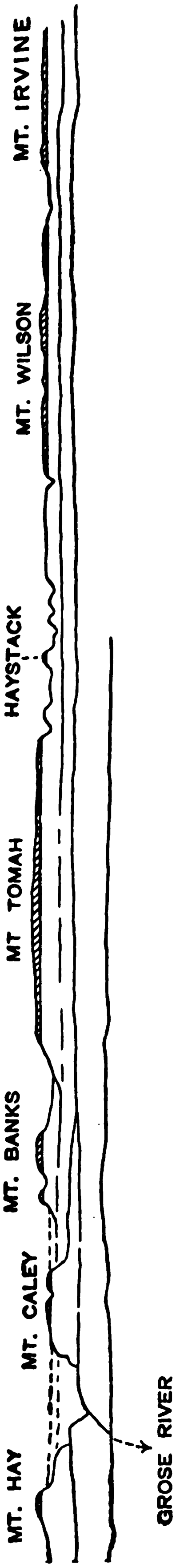


FIG. I.—Eastern aspect of basalt-capped summits on Blue Mountain plateau. Traced from photographs taken from near Cut Rock, Kurrajong Range by R. H. Cambage, L.S.

(*Basalt represented by diagonal hatching.*)

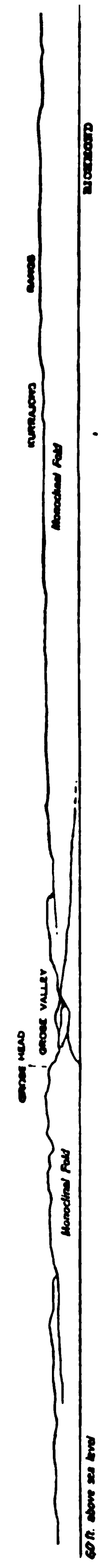


FIG. II.—Eastern face of the Blue Mountains viewed from the coastal plain near Richmond. Drawn from photographs taken by Messrs. C. T. Musson and W. M. Carne.

PART II.

IV.—GEOLOGY.

TABLE OF FORMATIONS.

a.	Recent		Alluvium	Not shown on maps.
b.	Tertiary		Pleistocene	
c.	Mesozoic—Trias		Wianamatta Shales.	
d.			Hawkesbury Sandstone.	
e.			Narrabeen Beds.	
f.	Palæozoic	Permo-Carboniferous	Upper Coal Measures.	
g.			Upper Marine Beds.	
h.			Devonian.	

Igneous.

i.	Tertiary	Superficial basaltic flows, in places covering drifts.	
j.	Post-Triassic	Volcanic Necks, with basalt, tuffs, and agglomerates.	
k.		Dykes.	
l.	Post-Triassic	Laccoliths (Tinguaite).	
m.		Sills (basalt and dolerite).	
n.	Post-Devonian [(?) Carboniferous]	Massifs	Quartz felsite and granite.
		Dykes	

RECENT AND TERTIARY.

Recent superficial deposition within the productive coal areas, owing to plateau elevation and torrential character of stream action, has been so slight as to be negligible, and is not shown on the present maps.

Tertiary deposits are confined to small protected patches of channel fillings in the isolated volcanic areas. On page 18 reference will be found to gold-bearing and other drifts under basalt flows. No direct evidence has, as yet, been obtained on which to definitely assign these drifts to a precise division of the Tertiary, and this applies also to volcanic necks, dykes, sills, and laccoliths; collateral evidence, however, points to their being of Pleistocene age.

In one instance auriferous drift has been worked under interesting conditions. Airly and Morundurey Mountains (Sheet 13)—where the Genowlan Kerosene Shale deposit is situated—consist of an isolated mass of Triassic and Coal Measure strata within the Capertee Valley, partially divided by Genowlan Creek.

Above the village of Airly, at the top of the Coal Measures, vertical cliffs of the Hawkesbury Series rise over seven hundred feet, reaching a total elevation of about three thousand three hundred and twenty-five feet above sea-level. Here an old channel filling or "lead" is partially exposed by denudation of the basalt cover, which still has a thickness of about thirty-five feet at the highest point above the Hawkesbury Sandstone.

For several hundred feet to the edge of the precipitous escarpment of the latter the auriferous drift has been worked more or less profitably for gold. It consists of large boulders of well-rounded quartz and quartzite, with smaller pebbles of the same.

Somewhat similar buried drifts are preserved under the basalt at Mounts Irvine and Tootie (Sheet 12), and Jonathan's Nob, north of the Colo River (Sheet 14). It is probable that gold also is present.

It is interesting to note the probable derivation of the quartzites from the Devonian formation of the Mount Lambie District. The fossil wood, noted in the drift as far north as Jonathan's Nob, is of itself valuable evidence of the elevation and inclination of the Coal Measures (from which it was probably derived) on the flanks of the original high Devonian range forming the watershed of the ancient plateau streams. Nor are these obsolete channels less attractive as criteria of age. Between them and their source great gaps occur excavated by subsequent denudation. The profound canyons dissecting the plateau have all been carved since they flowed over it.

The old channel at Lapstone Hill, near Emu Plains, with its burden of quartz-felsite boulders and pebbles, is probably still more ancient. It shared in the great monoclinal folding which depressed the Penrith-Sydney area, and steeply bent the massive plateau sandstones to form the eastern face of the Blue Mountains above Penrith, as may be well seen in the railway cuttings near Glenbrook tunnel from Emu Plains.

The watershed of this old stream was the original high quartz-felsite range towards Wombeyan, through which the later Wollondilly has cut its channel, and in which The Peaks silver-lead lodes occur.

These streams, moreover, afford reliable evidence of coincident regional inclination and stream trend of past and present periods in the plateau genesis.

Recent discovery of an ancient river channel falling in a general north-westerly direction,[1] connecting the Shoalhaven and Wollondilly watersheds, strengthens the testimony above cited.

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[1] W. G. Woolnough and T. G. Taylor, Proc. Linn. Soc. N. S. Wales, 1906, XXXI, Pt. 3, p. 548.

MESOZOIC.

Hawkesbury Series—Trias.

I. Wianamatta Stage.
II. Hawkesbury Sandstone Stage.
III. Narrabeen Stage.

I. *Wianamatta Stage.*—The Wianamatta Beds—so named by the Rev. W. B. Clarke because of their great development along Wianamatta or South Creek—consist chiefly of shales with occasional carbonate of iron and coaly bands. Oxidation of the former gives rise to limonite, and the red and brown stainings noticeable in outcrops.

The shales form excellent brick and pottery material, and are extensively used in the metropolitan area. Their maximum thickness approaches seven hundred feet, according to the above authority,[1] probably in the Campbelltown and Picton districts, where they are conspicuously represented in rounded hills and ridges. Occasionally beds of sandstone are intercalated.

In the country under review the Wianamatta Beds appear in Sheet 12 only, and to a very limited extent. They are seen along the Great Western railway at intervals as far as Faulconbridge, and along Bell's Line near to and under Mount Tomah, where a thickness of one hundred to one hundred and fifty feet has been measured under a cover of basalt.

Under the basalt caps of Mount Banks (or King George), Irvine, and Tootie, the Wianamatta is also preserved. In each case, including Tomah, they fail to appear on the western slopes; the boundary in that direction evidently coinciding with the transverse ridges on which these are situated.

Apart from the grassy covering which distinguishes small patches of Wianamatta shales amid the scrubby vegetation of the plateau, they can be detected from a distance by the presence of the shapely turpentine-tree (*Syncarpia laurifolia*), and the absence of the smooth-barked apple-tree (*Angophora lanceolata*), which hovers round the margin with roots in Hawkesbury Sandstone soil.

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[1] C. S. Wilkinson, Min. Prod. N. S. Wales, 1887, p. 76.

North of the Colo, on the old stock-route from Singleton to Richmond, thin coatings of the Wianamatta shales occur for some miles on the main ridge followed by the road; this locality, however, is east of the present maps.

A list of fossils contained in this stage will be found on p. 40.

Hawkesbury Sandstone Stage.

In studying the literature of the Trias the author has been greatly impressed by the remarkable coincidence of the Triassic formation of Connecticut with that of New South Wales.[1] The description, from which the salient characteristics have been extracted, needs but an alteration in name to fit local conditions. The writer's attention was drawn to it by Mr. E. C. Andrews.

The principal features of these rocks are prevalent eastward inclination at moderate angles; stratigraphic evidence indicating deposition under comparatively uniform conditions as to depth. No direct evidence of marine deposition; no marine fossils,—save one doubtful local instance. Fish remains allied to fresh or brackish water forms, land plants, etc. If marine, the waters must have been littoral and shallow, and the bottom frequently bared to the sun. Conclusive evidence of which is furnished by cross-bedding ripple marks, mud-cracks, rain-prints, and footprints of animals at various horizons; these being the commonest of the detailed structures in Triassic strata. To quote Professor Davis (pp. 34-35): "Perhaps the most noticeable feature of all this time is that, in spite of the great depths of the Triassic basin, as measured in the total thickness of its strata, by far the greater number of its layers give clear evidence of having been deposited by streams, or in comparatively shallow water; thus repeating the geological paradox, encountered in many other regions, of a shallow basin always filling, and yet never becoming filled."

Footprints of animals have not been noted in the New South Wales formation, but this is merely an incident, as *Labyrinthodont* remains have been discovered at Woy Woy, Cockatoo Island, St. Peters, and Bowral.

One marine gasteropod, ***Tremanotus Maidenii***, Eth. Jun., was reported to have been discovered in Hawkesbury Sandstone, at Cockatoo Island, during the excavation of Sutherland Dock, at a depth of twenty-five feet.[2]

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[1] W. M. Davis, 18th Ann. Rept. U.S. Geol. Surv., 1896-7, Pt. II.

[2] Memoirs Geol. Survey N. S. Wales, Pal. I, 1888, p. 18.

Until further evidence is forthcoming of marine shells *in situ* in the sandstone, it may be wise to suspend acceptance, particularly, as Mr. Etheridge points out, that *Tremanotus* in Triassic rocks marks a most remarkable survival of a Silurian form.[1]

Its presence in these beds may have been due to transport from an older horizon during deposition of the sediments in which it is presumed to have been embedded, as suggested by Mr. Etheridge, who was disinclined to base any discussion as to the age of the Hawkesbury Series on its occurrence.

Careful re-examination of the fossil reveals replacement of the original calcareous shell by *true quartz*, which, in the Writer's opinion, casts grave doubt on the authenticity of the discovery in the solid rock at Cockatoo. In no instance, so far as known—disregarding silicic infiltration or fusion around peripheries of volcanic necks—has a true quartz vein or replacement been observed in the Hawkesbury Series. If such had taken place *in situ*, at Cockatoo, there should be corroborative evidence. If *Tremanotus* was adventitious and preserved entire (owing to previous silicification) during transport stress producing such finely-comminuted waste, it is difficult to accept it as a solitary survivor of similarly protected forms with which it must have been associated.

From particulars kindly furnished by Mr. J. H. Maiden, F.L.S., Government Botanist, &c.—through whom the discovery was made known—the occurrence of the fossil *in situ*, but not the finding, is open to question. The finder, Mr. J. Fagan, a Dock Engineer, picked it up amongst the débris from previous blasts. Cockatoo Island, in which the dock has been excavated, is of very small area and has been inhabited from the early days of settlement. The possibility therefore arises of a specimen of foreign origin falling from the inhabited higher levels into the quarry during blasting concussions—just as a couple of small stone implements of Red Indian manufacture worked from the cliff surface to the quarry floor at Carson City gaol, Nevada, under similar circumstances, and were locally stoutly claimed as belonging to the lower level, where innumerable extinct animal tracks are preserved.

The Hawkesbury Sandstone, so well known in the bold coastal headlands of Port Jackson and in the upper levels of the Blue Mountain canyons, has been frequently described. It is proposed herein to deal with special features, and with problems which have since arisen.

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[1] Ann. Rept. Dept. Mines for 1886, pp. 174-176.

They occur also at Upper Colo, and could doubtless be traced down that stream well towards its junction with the Hawkesbury at Portland. In such case a reliable estimate of depth to coal at the confluence would be possible.

On the section from Lithgow to Cremorne an estimate of the depth to coal at the Nepean level above Penrith, will be found, based on Chocolate Shales in the Woodford and Penrith Bores; the latter being, as previously reported by Professor David,[1] too shallow. His estimate being about nine hundred feet below the bottom of the Penrith Bore four hundred and thirty-four feet deep, or from one thousand three hundred to one thousand four hundred feet below the surface to the top or Katoomba Coal-seam.

The Breakfast Creek Bore close by was continued to seven hundred and thirty-seven feet,[2] or between six hundred and seven hundred feet too shallow.

Correlation (?) of Hawkesbury, Clarence, and Artesian Series.

The most interesting and important question which has arisen in connection with the Hawkesbury Series, is their reported correlation with the Clarence and Artesian Series,[3] which latter are regarded in this State as identical.

The progress of the geological survey westward, along the margin of the Permo-Carboniferous basin, with gradual approach to the Talbragar, or Ballimore Coal Measures (each with its cover of the Hawkesbury Series) and proximity of the Artesian Beds, reawakens the, as yet, unsettled question of stratigraphical relationship of the former, and possible correlation of the latter.

These subjects are of extreme importance, and an attempt has been made to draw deductions from evidence gained during a prolonged and careful examination of the Western Coal-field, and during several visits to the Clarence Measures.

The announced identity of the Hawkesbury Sandstone with the "intake beds" of the artesian area, naturally claimed close attention whilst mapping several thousand square miles of it overlying the Western Coal Measures, and when following it further afield, from the Cambewarra on the south to Gunnedah on the north, and Dubbo on the west, because, if established, the eastern limit of the "intake beds" comes within the area mapped.

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[1] Ann. Rept. Dept. Mines for 1889, pp. 229-30.
[2] Ann. Rept. Dept. Mines for 1884, p. 180.
[3] E. F. Pittman, Ann. Rept. Dept. Mines, N. S. Wales for 1905, p. 137.

At the commencement of the field work the identity was accepted as proved, but as conflicting facts were accumulated other deductions appeared necessary—one of the not least conflicting being the existence of a dry, yet typically artesian-form basin of the Hawkesbury Series between Penrith and the coast.

This warped area of relatively porous (?) beds is sealed over by impervious Wianamatta shales, yet all the deep drill bores, and the coal shafts at Balmain which penetrated it near its deepest part to over three thousand feet, were practically dry !

The inclination of the basin bottom, between Cremorne and Balmain, taken in conjunction with its levels at Moore Park and Liverpool, probably establishes its centre near Parramatta.[1]

From the lower portion of this deep depression there is no outlet, whilst into it the Hawkesbury Series are steeply folded from the west, and should, even if moderately porous, absorb a perennial water supply from the permanent streams flowing through deeply-intersecting canyons from the Blue Mountains, as well as from the ordinary rainfall.

Warping, though less sudden, is also pronounced both to north and south of the basin, as is shown by the elevation of the Hawkesbury Series in these directions.

It is significant that neither artesian nor sub-artesian water has ever been found in the undoubted Hawkesbury Series, even under these ideal conditions.

In the Clarence Series on the coast outside of the proved artesian area, in the only two bores put down—so far as the Writer is aware, disregarding the shallow bore at Maclean—at Brisbane and Grafton, artesian water was struck in both, in one case not potable, in the other not permanent.

The Eagle Farm Bore near Brisbane struck water at one thousand five hundred and thirty-five feet and one thousand seven hundred and seven feet, the maximum yield discharging three feet nine inches above the surface.

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[1] T. W. E. David, Journ. R. Soc. N. S. Wales, 1906, XXX, p. 47.

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The intensely interesting question of correlation of the Hawkesbury with the Clarence and Artesian Series, which must arise upon investigation of any of them, is foreshadowed in the following statement, by Mr. E. F. Pittman and Professor David, in a paper on "Irrigation, geologically considered with special reference to the Artesian area of New South Wales":—"Wherever the term Trias or Triassic is applied in this paper to rocks other than those of the Hawkesbury Series, it must be understood that the use of these terms is only provisional. It is quite probable that their age may eventually prove to be Jurassic, like that of the Victorian Series and that of the Clarence Series of New South Wales, as originally suggested by the late C. S. Wilkinson."[1]

One of the authors, however, has since definitely recognised the identity of the three series.[2]

Of the Talbragar or Ballimore Coal Measures near Dubbo, it is sufficient here to state that recent collection by the Writer of *Glossopteris*, *Vertebraria*, *Phyllotheca*, etc., from Spicer's Creek, near Ballimore, and from numerous other localities in the district by Mr. C. Murton, confirms previously recorded opinions as to their Permo-Carboniferous age. More extended reference will be found on p. 47.

Stratigraphical position of Clarence Series.

E. F. Pittman appears to have been the first to suggest a Jurassic age for the Clarence Beds,[3] C. S. Wilkinson followed tentatively,[4] and J. E. Tenison-Woods.[5]

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[1] Proc. R. Soc. N. S. Wales, 1903, XXXVII, p. cxxii.

[2] E. F. Pittman—Ann. Rept. Dept. Mines N. S. Wales for 1905, p. 137.

[3] Ann. Rept. Dept. Mines, 1879, p. 227; Ibid., 1884, p. 244.
Min. Prod. N. S. Wales, 1882, p. 55.

[5] Proc. Linn. Soc. N. S. Wales, viii, 1883, p. 53.

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Min. Prod. N. S. Wales, 1882, p. 55.

[5] Proc. Linn. Soc. N. S. Wales, viii, 1883, p, 53,

Feistmantel correlated the Clarence with Victorian and Queensland Coal-beds, which he classed as *Lower* or *Upper Jurassic*.[1]

A. Smith Woodward regarded Talbragar fish as *Jurassic*,[2] and R. Etheridge, writing of the plants associated with them, states :—" They are of the highest possible interest, as indicating an alliance of these rocks with those of the Clarence Series of New South Wales, the Ipswich of Queensland, and the Wannon and Bellarine Beds of Victoria. The most conspicuous plant is a *Tæniopteris*, which Professor McCoy is unable to distinguish from *T. Daintreei*, so characteristic of the Mesozoic deposits of Victoria." [3] To which he added :—" It is exceedingly probable, therefore, that, although of Lower Mesozoic Age, the beds containing the Talbragar fossils will be found to be higher, stratigraphically, than the Gosford fish-bed." [4] In the Narrabeen stage of the Hawkesbury Series.—J.E.C.

At a later date the same authority states in an introductory note to Dr. A. Smith Woodward's Memoir on the Talbragar Fish, that it now seems possible, after a careful study of the specimens in connection with the unique series of fossils fishes in the British Museum, to determine that the Talbragar strata are much newer than any other part of the Hawkesbury-Wianamatta Series that has previously yielded fish-remains.[5]

Mr. Pittman's opinion is contained in the following extract :—" From a geological point of view, the Clarence and Richmond district is remarkable for the occurrence of a large Carboniferous basin. The rocks forming the basin consist of pebble conglomerates and sandstones. The first or lowest are the conglomerates, which are composed of coarse pebbles derived from Siluro-Devonian rocks which underlie the whole of the basin, and which flank it upon the south and west in high ranges. Above these conglomerates occur coarse sandstones, more or less impregnated with iron, and having interstratified beds of shale containing coal-seams. The fossils which I found with the coal from these beds shows that they are much more recent than the Newcastle Series. They are, probably, of Jurassic age, and, therefore, similar to the Mesozoic Beds of Queensland and Victoria, as I found *Tæniopteris Daintreei*, *Thinnfeldia odontopteroides*, *Sphenopteris*, etc., which are characteristic of the latter beds." [6]

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[1] Geol. and Pal. Relations of the Coal and Plant-bearing Beds of the Palæ. and Mesozoic Age in E. Australia and Tasmania, 1890, pp. 50, 55, 56, Mem. Geol. Survey N. S. Wales, No. 3.

[2] Mem. Geol. Survey N. S. Wales, Pal. 9, 1895, pp. 26, 27.

[3] Ann. Rept. Dept. Mines N. S. Wales for 1899, p. 287.

[4] *Ibid.*, Pal. No. 7, 1890, p. 3.

[5] Mem. Geol. Survey N. S. Wales, Pal. No. 9, 1895, p. 1.

[6] Ann. Rept. Dept. Mines N. S. Wales for 1880, p. 244.

At a later date the Clarence Series began to be regarded as of *Triassic* age, the change being based on the supposed correlation of the Middle or Massive Sandstone division of the Series with the Hawkesbury Sandstone, as first suggested by the Rev. W. B. Clarke in a report, dated June 24th, 1853,[1] who also concluded that representatives of the Wianamatta were present in the district (*ibid.*, p. 10). He also recognised the resemblance of the massive sandstones on the western slopes of the New England table-land to those of the Hawkesbury River, in a report on the Geology of the Condamine Basin, dated October 14th, 1853 (*ibid.*, pp. 19–31): "Repecting the Carboniferous deposits on Darling Downs, a few further remarks may be necessary. In some places the beds are indistinguishable from those so powerfully developed in the great sandstone region of the Hawkesbury."

Again, in vol. ii, p. 353, in "Report VIII—On the Geological Structure of the Western Slopes of the Highlands of New England," dated 7th May, 1853, he states:—"Over the conglomerates of Reedy Creek [a tributary of the Gwydir, J.E.C.], sandstone quite indistinguishable from those of the great sandstone territory of New South Wales rise in succession till the formation attains a height of from one thousand three hundred to one thousand eight hundred feet above sea-level."

Mr. Clarke then regarded the Clarence and Hawkesbury as part of the Palæozoic Coal Measures of New South Wales.

In 1870 he classed the Clarence with similar Queensland and Victorian beds as *Trias*, querying the Queensland, however, whilst still retaining the Hawkesbury Series as Palæozoic.[2]

Mr. C. S. Wilkinson followed this classification in 1875.[3]

The Rev. Tenison-Woods also pointed out the resemblance of the Queensland Sandstones, as developed between Brisbane and Toowoomba, Murphy's Creek, etc, to the Hawkesbury Sandstone of Sydney.[4] He, however, bracketed both as *Jurassic*, placing the Hawkesbury Sandstone lowest.[5]

The Queensland beds referred to by the above authorities undoubtedly correlate with the massive current-bedded sandstone overlying the Clarence Coal-seams.

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[1] Gold Discovery Records, 1855, iii, p. 11.
[2] Industrial Progress of N. S. Wales, 1870, p. 524.
[3] Mines and Mineral Statistics, 1875, pp. 127, 128.
[4] Proc. R. Soc. N. S. Wales, XVI, 1882, p. 57.
[5] Proc. Linn. Soc. N. S. Wales, VIII, 1883–4, p. 53.

The Rev. J. M. Curran reversed the stratigraphical order adopted by Tenison-Woods, stating that he could "see no reason for separating the Hawkesbury and Clarence by any great interval, and more, I think the Clarence the older of the two. The Ballimore Coal-field, with its own marked flora, I take to be older than either."[1]

It may here be mentioned that both Tenison-Woods and Curran regarded the Ballimore Coal Measures as Mesozoic; the former classing them as *Rhætic*, or Lower Lias,[2] Curran's classification being in descending order:—

1. Hawkesbury and Wianamatta;
2. Clarence;
3. Ballimore;
4. Upper Coal Measures.[3]

This classification was based on Tenison-Woods' identification of the following forms in Curran's Ballimore collection. Others were included, but reference to Tenison-Woods' paper casts doubt on the localities. It is also doubtful whether *Alethopteris concinna* came from Ballimore.

Sphenopteris crebra	... ...	Ten.-Woods	
" *glossophylla*	...	"	
Alethopteris concinna ...	...	"	Ballimore (?)
" *Currani* ...	...	"	Ballimore.[4]

It is necessary to bear in mind that Mesozoic Beds—Hawkesbury and Narrabeen—are typically represented in the cliff sections at Ballimore; a maximum thickness of forty to fifty feet only of the Coal Measures being exposed above the river channel, whilst the former have an aggregate thickness of about two hundred and fifty feet. From the latter the Mesozoic fossils recorded may have been obtained; in the absence of direct evidence that they were from beneath the coaly outcrops, they are without value for stratigraphical purposes.

C. S. Wilkinson, following Curran, regarded it as not improbable that the Clarence Series are the equivalents of the Chocolate Shales at the base of the Hawkesbury Sandstone, "in which case they may be of Triassic age."[5]

At a later date, after personal inspection, Mr. Wilkinson wrote:— "During a recent examination (in April, 1889) of the Clarence River district, I discovered that its coal-bearing series, containing *Tæniopteris* and

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[1] Proc. Linn. Soc. N. S. Wales, X, 1885-6, pt. 2, p. 181.
[2] Proc. Linn. Soc. N. S. Wales, VIII, 1883-4, p. 53.
[3] Proc. Linn. Soc. N. S. Wales, X, 1885-6, pt. 2, p. 181.
[4] Proc. Linn. Soc. N. S. Wales, VIII, 1883-4, pp. 93, 94, 112-114.
[5] Min. Prod. N. S. Wales, 2nd ed., 1887, pp. 71, 72.

Alethopteris Australis, is overlaid by beds of sandstone about four hundred feet thick, identical with the Hawkesbury formation, which latter has been finally determined, upon the evidence of its fossil fauna, *Labyrinthodonts*, *Palæoniscus*, &c., to be of Triassic age. It is not improbable, therefore, that the Victorian Carboniferous Series, which, on account of their characteristic fossils *Tæniopteris Daintreei* and *Alethopteris Australis*, have hitherto been considered of Jurassic age, may be the equivalents of the Clarence Series, as here suggested by Professor Feistmantel, and may also be of Triassic age."[1] The present consensus of opinion, however, is against this conclusion.

Professor T. W. E. David credits Mr. Wilkinson with the opinion that the key to the geology of the Clarence Coal-basin is the "occurrence in it of extensive and thick beds of whitish sandstone," which he regarded as the probable equivalents of the Hawkesbury Sandstone of the Sydney Basin (?); and goes on to say that Mr. Wilkinson "describes this massive sandstone series as occupying an intermediate position between the *Upper and Lower Coal-beds* of the Clarence basin, so that it may not inappropriately be termed the Middle Clarence Series. Its strong outcrop, wherever developed, and its persistency, will render it a very useful guide to future geological workers in this district, and it is an extremely valuable indication for localising the outcrops of the principal seams of coal which have been discovered in the north-eastern portion of New South Wales. If the sandstone series be found to be identical with the Hawkesbury sandstone, it may be possible to correlate the Upper Clarence series with the Wianamatta shales, which overlie the Hawkesbury sandstone at Sydney; and the Lower Clarence series with, perhaps, portions of the Narrabeen shales, which underlie the Hawkesbury sandstone."[2]

"Part, at any rate, or possibly the whole of the Clarence group of coal measures, continue northwards into Queensland, and in the neighbourhood of Ipswich, and near Brisbane and Clifton, contain productive seams of coal. It is as yet, however, uncertain whether the coal-bearing strata at Ipswich should be correlated with the Upper, Middle, or Lower Clarence series. A very important point would be gained towards this correlation if the Middle Clarence (or Hawkesbury) sandstone could be identified near Ipswich, and its horizon, with regard to the Ipswich coal-seams established."[3]

In 1891 Mr. Robert Etheridge identified *Tæniopteris* in strata pierced by the Nyngan (subsequently proved) sub-artesian bore, and in pointing out that it was characteristic of the section of the Mesozoic in New South

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[1] Mem. Geol. Survey N. S. Wales, Pal. 3, p. 41.

[2] Ann. Rept. Dept. Mines for 1891, pp. 220-229.

[3] *Ibid.*, p. 222.

Wales known as the Clarence Series stated: "The latter is, probably, the equivalent of some part of the Ipswich Coal Measures, in Queensland, where the fern also occurs. It is likewise found in the typical Clarence district, and in the 'Carbonaceous' Coal Measures of Victoria"[1]

In 1895 Mr. E. F. Pittman discovered *Tæniopteris Daintreei* in drill cores from the flowing Moree artesian bore, two thousand seven hundred and ninety-two feet deep, and announced that the strata in this and the Coonamble bore were also equivalents in age of the Clarence Series.[2]

This discovery in the drill cores after an abundant artesian supply had been struck, established the association of this plant with the lower water-bearing beds.

Clarence Series identical with Artesian Beds, and with Hawkesbury Sandstone (?).

Mr. E. F. Pittman identified the Middle (?) Clarence (Hawkesbury Sandstone of Mr. C. S. Wilkinson) with the artesian basin, "intake beds." To quote: "Again on the western flanks of the Dividing Range, these Mesozoic rocks (Middle Clarence Series) outcrop, and form the intake beds of the great artesian water basin of New South Wales."[3]

This opinion has recently been further emphasized by the same authority, who definitely identified the Hawkesbury Sandstone of the Sydney water supply catchment at Cataract River, and the Blue Mountains as the "intake beds of the artesian area"[4]; thus embracing all the widely extended Hawkesbury Sandstone on the mountains and along the coast.

Apart from the lithological resemblance of portion of the Clarence Series to certain sandstones of the Artesian Area, palæontology establishes a relationship, which at the same time differentiates each from the Hawkesbury Series.

Tæniopteris Daintreei, which has been accepted as the distinctive fossil of the Clarence, is present in the Artesian Beds, in the correlated Ipswich Measures of Queensland, and in those of Bellarine and Wannon in Victoria; but has never been found in the Hawkesbury Series.

It is, moreover, significant that in the only instance where it has been found in beds closely associated with undoubted Hawkesbury rocks—at the Talbragar Fish Beds—both Professor David and Mr. Pittman agree "that

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[1] Ann. Rept. Dept. Mines N. S. Wales for 1891, p. 320.
[2] Ann. Rept. Dept Mines for 1895, p. 123.
[3] Mineral Resources N. S. Wales, 1901, pp. 310, 311.
[4] Ann. Rept. Dept. Mines for 1905, p. 137.

the stratigraphical evidence obtained would seem to indicate that these beds were deposited in a *hollow of erosion* in the sandstones of the Hawkesbury Series"[1]—an opinion with which the Writer is in complete agreement.

The reasons given for this conclusion being:—

(1) "The Fish Beds differ in lithological character from any rock known to occur elsewhere in the Hawkesbury Series.

(2) "They thin out rapidly against the sandstones of the latter formation, which rises to a considerable height on their margin, and is nowhere seen to overlie them."

The authors, after considering Dr. A. Smith Woodward's arguments as to Jurassic age of the Talbragar fossil fish, and Mr. R. Etheridge's report on the associated fossil plants, were of opinion that the balance of the evidence was in favour of that age.[1]

Contemporaneous erosion might, perhaps, be considered, but the absence of *Tæniopteris Daintreei* in the eroded Triassic beds, and the association of fish of a Jurassic facies with that plant in abundance in the later deposit, indicate unconformability both stratigraphical and palæontological.

FOSSILS from the Talbragar Fish Beds.

Plantæ.

Tæniopteris Daintreei, *McCoy*	Identified by R. Etheridge, jun.
Podozamites lanceolatus, *Lind. & Hutt.*	
„ spathulatus, *Feistm.*	
„ longifolius, *McCoy*	
„ sp.	
Thinnfeldia odontopteroides	
„ sp.	
Taxites (?) cf. T planus, *Feistm.*	Identified by W. S. Dun, in addition to above.
Neuropteridium australe, *Ten.-Woods*	
Sphenopteris, sp.	

Insecta.

Cicada (?) Lowei, *Eth. & Oliffe.*

Pisces.

Cockabutta, Talbragar River.

Coccolepis australis.
„ (?) sp.
Aphnelepis australis.
„ sp.
Aetheolepis mirabilis.
Archæomæne tenuis.
„ robustus.
Leptolepis talbragarensis.
„ Lowei.
„ gregarius.

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[1] Mem. Geol. Survey N. S. Wales, Pal. 9, 1895, p. xiii.

Again, *Macrotæniopteris*, so abundant in the Hawkesbury Series, has never been found in the Artesian beds, and only at the very base of the Clarence Coal Measures. (See page 34.)

Fish remains associated with *Tæniopteris* at Talbragar are distinct from and palæontologically younger than any of the numerous species discovered in the Hawkesbury Series.[1] Neither have Labyrinthodont remains, or the abundant *Estheria* of the latter, yet been found in the Clarence Series. (The Artesian Beds are, naturally, not mentioned, because of limited exposure; but the Clarence are provisionally accepted as identical.)

Other marked—and, to the Writer, insuperable differences—between Clarence and Hawkesbury Series, are the numerous *Coal-seams* (some of great thickness), and abundant ferruginous fossil wood of the former, unrepresented in the latter.

On the other hand, in the Clarence there is marked absence of the Chocolate Shales which divide the Hawkesbury Sandstone (supposed Middle Clarence) from the Narrabeen Beds; and which are so remarkably persistent throughout the entire extent of the Hawkesbury Series, from the Cambewarra in the South Coast, to Camden Haven on the north, and at least to Gunnedah in the north-west, and as far west as Ballimore, near Dubbo, where, as before stated, the whole series have a diminished thickness of only about two hundred and fifty feet.

At Silverwood, and near Warwick (Queensland), what appear to be the Chocolate Shales are seen at the base of the Ipswich or Clarence Measures, resting directly on folded Lower Marine strata, containing ***Productus brachythærus*, *Spirifer Stokesi*** (?), ***Martiniopsis subradiata***, var. ***Morrisii***, and Crinoid stems.

In the Silverwood cutting, at the 178¾ railway mile peg, these Chocolate Shales are interbedded with tuffs and agglomerates.

Near Warwick, on the bank of Joyce's Creek, they are seen overlaid by conglomerates and then sandstone devoid of fossil wood. These in turn are overlaid by characteristic Clarence sandstones containing ferruginous fossil wood in abundance.

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[1] A. Smith Woodward, Memoirs Geol. Survey N. S. Wales, Pal. 4, 1890, pp. 54-55; *ibid.*, Pal. 9, 1895, p. 27.

These facts, in conjunction with occurrence of the true Hawkesbury Sandstone *Thinnfeldia*, and of *Macrotæniopteris*, with *Tæniopteris Daintreei*, in a similar basal position near Nymboida, seem to the Author to indicate thinning out of the Hawkesbury Series and subsequent deposition of the Clarence, with brief survival of Hawkesbury *Thinnfeldia*, and Wianamatta *Macrotæniopteris.*

The small outliers at Camden Haven and Grant's Head contain representatives of the two main divisions, separated by typical chocolate shales.

The upper division consists of about one hundred and fifty feet of jasperoid and chalcedonic pebbles and quartz, exactly resembling the thick conglomerate series at Murrurundi, Curlewis, and Black Jack, with which they correlate, but where sandstones occur above the conglomerates.

At Curlewis a thin bed of chocolate shales occurs just above the top conglomerate.

Unlike the basal beds of the Clarence Series, those of the localities mentioned contain no trace of the fossil wood, which forms such an abundant and remarkable feature of the former nor any trace of coal throughout.

It is interesting to note that the Camden Haven and Broken Bago Triassic outliers overlap the Upper Coal Measures and rest upon Permo-Carboniferous Lower Marine Beds, containing *Fenestella fossula, Strophalosia, Eurydesma cordata, Aviculopecten Mitchelli,* &c., and Crinoid stems.

The Permo-Carboniferous have here been greatly disturbed by the intrusion of the massive quartz-felsites of Broken Bago, North Brother, and Diamond Head.

If the Hawkesbury, Clarence, and Artesian Beds were *synchronously* deposited, it is difficult to reconcile the discordant results cited.

That the conditions in each were equally favourable for development and preservation of plant life must be conceded from a study of the facts, so far at least as mere sedimentation is concerned.

The basin of the Hawkesbury Series extended for at least two hundred and fifty miles along the present coast-line, and inland at least one hundred and eighty miles.

The southernmost coastal extension of the Clarence Series—near Woolgoolga—presents a bold escarpment reaching nearly eleven hundred feet above sea-level. The northerly dip indicates southern prolongation at increasing elevation. The northerly dipping Hawkesbury Series of Camden Haven are at sea-level. To connect them with the former, demands reversal of dip or profound faulting, of which there is no apparent evidence.

In the Clarence Series coal-seams occur, likewise in the adjoining—through Queensland—Artesian Basin on the west; and in the correlated Wannon and Bellarine Beds of Victoria. In each of these, north, south, and west of the Hawkesbury Series, an identical flora evidences similarity of life conditions prevailing during deposition. Such being the case it is difficult, as before stated, to account for the absence of coal-seams and of a peculiarly distinctive plant form—*Tæniopteris Daintreei*—in a supposed synchronously-filled basin (the Hawkesbury), almost surrounded by others containing both in abundance. More especially when it is borne in mind that the intervention of the six hundred miles coast-line of New South Wales has failed to differentiate the floras, or effect the coal deposition, of the Bellarine and Wannon beds of Victoria from those of Southern Queensland.

Again, the aggregate area of these formations, with those of the Clarence and Artesian, must have exerted preponderating influence in determining life development and distribution if the Hawkesbury Basin was synchronously filled.

Nor can any character of sedimentation in the latter be adduced to differentiate it from the others, either in the nature or abundance of the flora. The lower beds—Narrabeen—in fact, present more favourable conditions for accumulation and preservation of abundant plant remains in the Sydney and Blue Mountain areas, than the corresponding division of the Clarence; the former being shaly, the latter coarsely conglomeratic. Yet the Clarence conglomerates contain coal-seams and abundant fossil wood of large diameter.

Even where the nature of the sedimentation conforms closely, as from Gunnedah south-easterly to between the Hunter and Hawkesbury Rivers, and westerly from the Hunter to the Talbragar where the lower beds of the Hawkesbury Series are almost as coarsely conglomeratic as those of the Clarence, the same discrepancy exists; the former are as singularly devoid of coal-seams and fossil wood as the latter are conspicuous for them.

The Writer has, so far, been unable to discover any satisfactory reason for separating the Clarence Measures into three divisions based on the supposed correlation of the "Middle" Sandstones with the Hawkesbury Sandstone, and its separation of the Upper (?) and Lower Coal Beds.

Above the prominently escarping sandstones immediately overlying the top Clarence Seam the strata become more laminated, and occasionally shaly, as in the river-bed at Casino, but no coal has yet been discovered in them to justify the term "Upper" Coal Beds.

The Ipswich coal-seams, with one doubtful exception, are also *beneath* massive current-bedded sandstones undoubtedly identical with those of the Clarence.

The exceptional seam—the Purga—is separated from the rest of the coal-seams by much disturbed and faulted strata. Its super-position, as at present believed by the Queensland Geological Survey, has yet to be demonstrated.

W. E. Cameron, however, mentions a coal-seam in a shaft near Walloon, on a higher horizon than those to the east and north of Ipswich.[1] The coal is, moreover, distinguishable from ordinary Ipswich coal by a greater proportion of volatile hydrocarbons.

So far, however, as the Writer's examination of the Clarence has proceeded, the Upper, or Walloon, Coal Measures have not been observed in New South Wales.

Correlation of the Middle (?) Clarence with the Hawkesbury Sandstone was based on purely physical resemblance, particularly as regards cliff escarpments and current bedding. On these alone the likeness is remarkable. But resemblance is a mere natural coincidence of similar modes of deposition and weathering, not necessarily contemporaneous.

Massive sandstones and current bedding are a consequence of shallow deposition of arenaceous sediments in a subsiding basin; and are characteristic of all periods, though best preserved in those least subjected to metamorphism. Ignoring the effects of the latter, Devonian deposition in this State—at Eden, Nungatta, and the Harvey Range—is an instance in point.

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[1] Geology of the West Moreton or Ipswich Coal-field, 1899, p. 4.

The relatively impervious nature of the Hawkesbury Series is in strong contrast to the porosity of the Artesian. As already pointed out, the Sydney-Penrith warped area conforms to all the conditions of an ideal Artesian basin, yet all the deep-drill bores of Liverpool, Newington, Moore Park, Cremorne and Narrabeen—four of which pierced the entire Hawkesbury Series at its maximum thickness—were dry.

The Balmain Coal shafts—one over three thousand feet deep—sunk within one hundred feet of the waters of Port Jackson, are also practically dry, save for slight seepage down to about five hundred and sixty feet, amounting to two or three hundred gallons per hour. At this level a considerable fissure in the sandstone was cut in the Jubilee Shaft at an angle, which let in a flow of water equal at first to two thousand gallons per hour, but which lessened to one thousand five hundred before tubbing was completed. Since the fissure was sealed the soakage into the shafts only amounts to two hundred and three hundred gallons per hour in the two shafts. Below five hundred and sixty feet no water makes.

The fissure measured about two feet in width, and from the flow of water tapped it is probable that it is connected with the surface.

From the records of the first (Birthday) shaft it appears that the seepage of water down to four hundred and sixteen feet was about seventy-five gallons per hour. Below this level porous beds were met with at six hundred and seven, six hundred and seventy-two, and seven hundred feet, which increased the inflow of water to a maximum of six hundred and fifty-four gallons per hour. Below the seven hundred and twenty feet level it decreased gradually, the average being from four hundred and eighty to five hundred and ten gallons per hour.[1]

If the Hawkesbury Sandstone—pierced for about nine hundred feet below sea-level at Balmain—was identical with the porous intake beds of the Artesian area, it should be saturated with sea-water, to say nothing of fresh water from streams and rainfall already mentioned. The seepage and fissure water of the shafts, however, though containing a considerable amount of lime in solution, is not marine, as may be judged from the following analysis of rapidly-deposited encrustation in wooden water-pipe:—

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[1] J. L. C. Rae, E. F. Pittman, and T. W. E. David, Proc. R. Soc. N. S. Wales, 1899, xxxiii, p. 220.

BIRTHDAY Shaft, Balmain.

Moisture	0·38	per cent.
Calcium Carbonate	97·46	„
Barium Carbonate	0·32	„
Strontium Carbonate	trace.	
Magnesium Carbonate	1·15	„
Ferric oxide and alumina	0·20	„
Silica	0·38	„
Sulphur Trioxide	trace.	
	99·89	

(Analysis by Mr. H. P. White.)

If the identity exists, the only alternative involves an abrupt change in the fundamental characters of the Hawkesbury Sandstone and Series—which are maintained unaltered and undiminished throughout thousands of square miles in its coastal extension, and inland to Ballimore and Dubbo · from relatively impermeable non-carbonaceous to greedily absorbent and coal-bearing strata.

If the two Series are identical, then the eastern limit of the Artesian Intake must accord with the Main Dividing Range between Ilford and Murrurundi; for disregarding occasional superficial basalt sheets, the Hawkesbury Series crown the divide between these points.

The identity of these formations would also necessitate a change in the stratigraphy Westerly from the coast at Sydney, where there is a proved thickness of two thousand nine hundred feet, the Hawkesbury Series gradually thin out wherever examination is possible, until at Ballimore they have diminished to about two hundred and fifty feet, where the presence of both divisions, separated by characteristic Chocolate Shales, evidences normal thinning.

To meet the great thickness of Triassic (?) rocks pierced below Tertiary, and Cretaceous beds, in bores at no great distance from the eastern margin of the Artesian, calls for rapid thickening of the Hawkesbury Series westward beneath the former; if they indeed form the storage beds.

It is noticeable and significant that the Clarence Series, on the Artesian margin about Warialda—like the Hawkesbury about the Talbragar—have diminished to thin cappings on Palæozoic rocks at no distance from great thicknesses of Artesian strata.

This interesting question may possibly be resolved by a traverse of the base of the Clarence and Artesian in the Clarence River district, and on the north-west falls of New England.

Turning to palæontological evidence, Mr. W. S. Dun, Palæontologist, to the Geological Survey, has kindly supplied the following correlation of Australian Mesozoic strata, based on fossils collected to date, which corroborates the views above expressed, that the Hawkesbury Series do not, on a palæontological basis, correlate with the Clarence and Artesian.

Jurassic ...	1. Talbragar Beds.	These beds specially characterised by *Tæniopteris Daintreei*.
	2. Clarence Coal Measures.	
	— Ipswich, Queensland.	
	— Leigh's Creek, South Australia.	
	— Cape Otway, Victoria.	
	— Tasmania (Lower Mesozoic) probably.	

Note.—Estheria in Ipswich; none yet noted in Clarence.

Triassic (in part)	3. Wianamatta Shales.
	4. Hawkesbury Sandstone.
	5. Narrabeen Beds.

Palæontology.

Triassic--Wianamatta ...	Equisetaceæ ...	Phyllotheca Hookeri.
	Ferns	Thinnfeldia odontopteroides. „ (small variety, lancifolia type). Cycadodopteris scolopendrina. Macrotæniopteris Wianamattæ. Sphenopteris. Pecopteris (?) tenuiflora. Gleichenia dubia (?) Thinnfeldia. Alethopteris Australis (rare).
	Ginkoales	Baiera multifidæ (= Jeanpaulia ? palmata).
	Cycadacæ	Pterophyllum (?) (one specimen, imperfect).
	Pisces	Palæoniscus antipodeus, Egerton. Myriolepis Clarkei, „ Cleithrolepis granulatus, „
	Labyrinthodontia ..	
	Mollusca	Unio (?) Wianamattensis, Eth., junr. „ Dunstani, „ Unionella bowralensis, „ „ Carnei, „
	Crustacea	Crustacea-Ostracoda (Cypris ?),

Palæontology—continued.

Triassic—Hawkesbury Sandstone. *Note.*—Not plant-bearing as a whole, mostly barren.		Ottelia præterita (in sandstone).	
	Ferns	Thinnfeldia odontopteroides (in sandstone and shale bands). Macrotæniopteris (*not* the Wianamatta species). Oleandridium lenticuliforme. Fructifications of Mount Piddington. Alethopteris.	
	Equisetum	Phyllotheca concinna. „ Hookeri. Equisetum.	
	Mollusca (?)... ...	Tremanotus Maidenii (see page 21).	
		Hawkesbury Series—Gosford Fish Beds, Woy Woy.[1]	
	Pisces	Gosfordia truncata, Smith Woodward. Myriolepis Clarkei, Egerton. „ latus, Smith Woodward. Apateolepis australis, „ Dictyopyge symmetrica, „ „ illustrans, „ „ robusta, „ Belonorhynchus gigas, „ „ gracilis, „ Semionotus australis, „ „ tenuis, „ Pristosomus gracilis „ „ latus, „ „ crassus, „ Cleithrolepis granulatus, Egerton. „ (?) altus, Smith Woodward. Pholidophorus gregarius, Smith Woodward. (?) Peltopleurus (?) dubius, „	
		Cleithrolepis granulatus, Egerton. Myriolepis Clarkei, „ Palæoniscus antipodeus, „	Regarded by Egerton as Permian (Quart. Jour. Geol. Soc. XX).
	Labyrinthodontia ...	Mastodonsaurus robustus, Stephens. Platyceps Wilkinsoni, „	
	Crustacea	Estheria Coghlani (imperfect). Abundant at certain horizons—notably about eighty-two feet above the top coal seam.	

Dr. Smith Woodward's recent examination of a suite of fossil fish from St. Peters, a suburb of Sydney, from brick-shale quarries in the Wianamatta Stage of the Hawkesbury Series (the results of which are shortly to be published in the Memoirs of this Survey), brings to notice fishes of the types of Ceratodus and the Port Jackson shark—instances of the survival and evolution of forms ranging from Devonian to Recent.

The St. Peters collection extends also the range of European Carboniferous types to Upper Trias—Wianamatta—in Australia.

The Narrabeen beds are apparently conformable on Upper Coal Measures in the centre of basin at Sydney.

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[1] A. Smith Woodward, Mem. Geol. Survey N.S.W., Pal. 4, 1890.

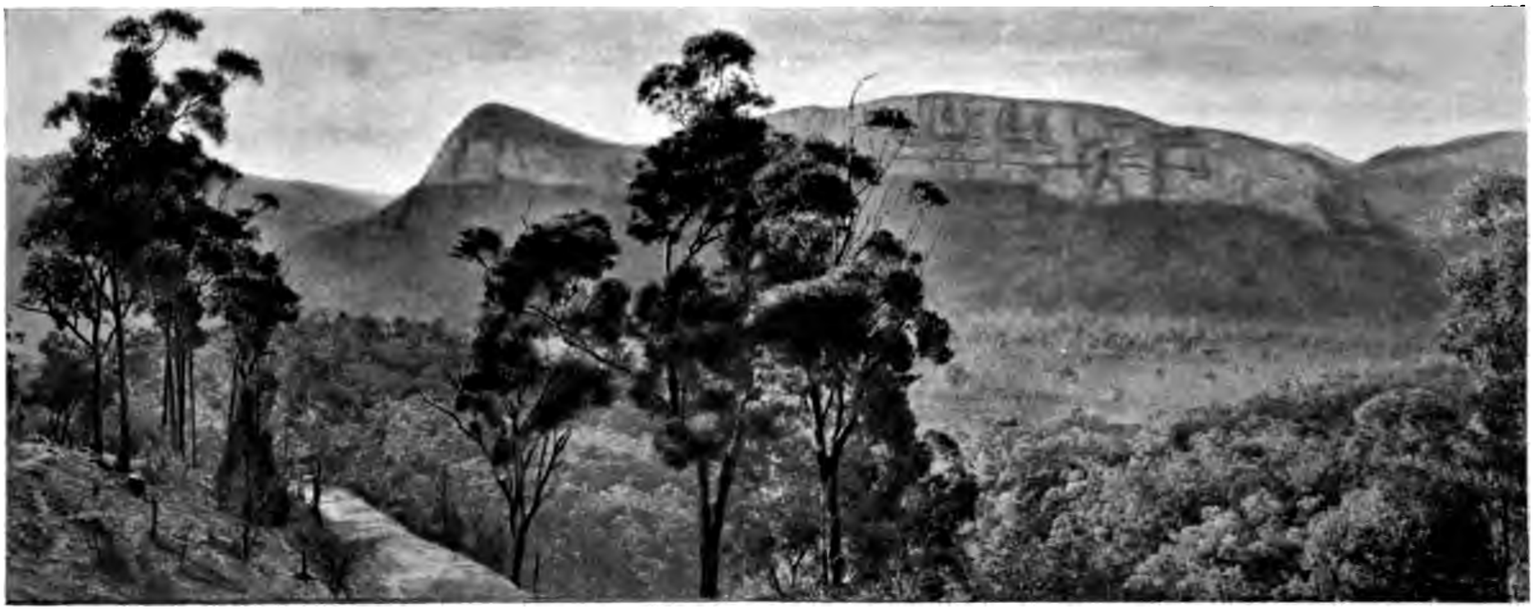
The Narrabeen is characterised by the great development of *Thinnfeldia* (with long pinnules). The forms with the ovate and reniform-cordate pinnules, so characteristic of the Hawkesbury Sandstone, are in the minority.

Triassic—Narrabeen.	Ferns ...	*Thinnfeldia*	*narrabeensis*, nov.
		,,	*lancifolia* type.
		,,	*odontopteroides* (Tasmanian typical form with long blunt pinnules).
		,,	,, (Hawkesbury Sandstone type).
		,,	(new sp. with very small acute pinnules).
		Alethopteris ...	The typical Australian type is absent—*Alethopteris* (*Cladophlebis*) of world-wide distribution in Jura-Oolite—but forms with smaller entire pinnules are present.
		Sphenopteris	Species of this genus are comparatively rare, and are referable to a new species.
		Tæniopteris ...	*Oleandridium* is fairly abundant and also a new species of *Macrotæniopteris*. It is possible that a new species of *Angiopteridium* is also present, but no trace of *Tæniopteris Daintreei* has been seen.
	Equisetaceæ	*Phyllotheca* is abundant, and *Schizoneura australis* is particularly well developed in the basal portion of the stage.	
		Equisetum—a large species occurs.	
Narrabeen ...	Coniferæ ...	*Araucarites*—cones referable to this genus are abundant, and also some impressions of the stems of a cone which may belong to this comprehensive genus. A delicate conifer with ovate leaves occurs, which may possibly be referred to *Brachyphyllum*.	
	Ginkoales ...	A large form described as *G. dilatata*, var. *lata*, and a smaller undeterminable species which may be *Phœnicopsis*.	
		Various types of inflorescence and fructification similar to to those at Mount Piddington also occur.	
	Crustacea ...	*Estheria Coghlani*.	

Of a number of plants collected by the author from the Clarence River Coal Measures, Mr. Dun remarks :—" These collections afford further proof of the close relationship of these deposits to the Ipswich Coal Measures of Queensland and the Gippsland beds of Victoria."

" The flora shows very *definite* affinities to the old world Jurassic. It would appear advisable to (i) discontinue the use of the term Trias-Jura, usually applied to this formation by Australian geologists, and (ii) consider the Eastern Australian Mesozoic Coal Measures—characterised by the relatively great abundance of *Tæniopteris Daintreei* (= *Spathulatum*), *Alethopteris australis* (= *Cladophlebis denticulata*), and numerous types of Conifers and *Thinnfeldia*, together with the Lake Eyre beds as Jurassic. The flora is more variable than in the rocks of the Hawkesbury Stage, the *Thinnfeldia* being much more variable, delicate, and more lanceolate as regards the pinnule form."

PLATE VII.



Kerry & Co.

THE GULLIES CAPERTEE VALLEY SHOWING ESCARPMENTS OF THE HAWKESBURY SERIES OVERLYING THE COAL MEASURES.

Thinnfeldia, of the true Hawkesbury Sandstone type, and *Macrotæniopteris*, have recently been obtained by the Author from a small patch of whitish cherty shales resting on Palæozoic rocks, and underlying the Clarence Series on the western margin of the latter, four miles from the junction of the Nymboida and Grafton–Glen Innes roads.

PERMO-CARBONIFEROUS.

Upper Coal Measures.

The abrupt margins of the Upper Coal Measures, relatively defined in the Southern and Western districts by overlying cliffs of plateau sandstone, everywhere prominent and picturesque, are, perhaps, nowhere more remarkable and diversified than between Ilford and Lue in the Western Coalfield.

Massive superimposed Triassic sandstones, imparting boldness to the scenery, are here sculptured by denudation into rugged mural-faced headlands and frequent isolated masses. Marginal lines are broken by deep indentations, broadly curved, or following embouching streams up narrow valleys into rocky defiles.

Irregularities of the plateau are no less pronounced and varied; huge domed laccoliths, conical volcanic peaks, and flat coulee remnants intermingle in the skyline with the rugged sandstone outlines mentioned, from which rounded contours and gentle slopes differentiate them.

From the Main Dividing Range, trending sinuously through the Coal Measures between the eastern and western waters of the Goulburn and Cudgegong, the view is equally impressive, especially northerly, overlooking the Goulburn water-shed. Narrow fertile valleys, walled in by stupendous sandstone cliffs, with slopes of well-grassed Coal Measure shales.

The bold ramparts are broken at intervals by subsidiary valleys, each auxiliary having its own system of ramparts, indentations, and rocky defiles, with self-repetition in each minor branch.

The Bylong-road, after passing the imposing Bald Mountain laccolith, about nine miles from Rylstone, crosses the Main Dividing Range, from which it leads down into a remarkable amphitheatre, before making the actual descent into Growee Valley, through Gulph Gap—a narrow cleft in the enclosing sandstone cliffs cut by Gulph Creek.

The amphitheatre encloses a volcanic neck, unequally bisected by the Creek to a depth of over one thousand feet below its conical summit above the northern sandstone rim, which it dominates by one hundred and fifty feet.

For two-thirds of the circumference narrow, perpendicular cliffs, several hundred feet in height, form the verge of the crater, the outer edge presenting a sheer face to the valley, in which two interesting dykes are exposed, following irregular fissuring from base to summit.

Travelling down the beautiful Growee-Bylong Valley, glimpses are caught on the west of the dominant dome-like contours of Mounts David, Porcupine, and Stormy—huge laccoliths of Tinguaite (*Nepheline ægerine*) with inclined sandstone revetments.

Stormy Mount, rising eleven hundred and sixty feet above the valley at its foot, with a remnant of the sandstone mantle high on its eastern shoulder, affords a splendid illustration of laccolithic phenomena.

The exceeding fertility of these particular valleys in the plateau sandstone, compared with others more remote, is due to difference in geological and tectonic structure, the most important geological agents in the welfare of the Growee Valley system being two thick intrusive sills in the Coal Measures which occupy the slopes from the vertical cliffs to the valley bottoms.

Above the junction of Growee and Gulph Creeks, Coal Measures descend into the flats, but owing to the fall of the latter exceeding their inclination, they appear to rise along the valley slopes on its northerly trend, the basal Marangaroo conglomerate forming a well-marked escarpment. Beneath it, Upper Marine Beds outcrop, and are covered by deep alluvium in the flats. Near the top of the Marines, characteristic buff and chrome-coloured limestone bands occur, with veins or segregations of arragonite. Occasionally these bands are fossiliferous.

The lowest sill occurs just above the Marangaroo conglomerate, and is separated from the second by about fifty feet of Coal Measure shales.

As the valley deepened, these became exposed to denudation and yielded a strong rich soil, which, blended with Coal Measure shales, Hawkesbury grit, and Upper Marine calcareous debris, forms the prolific mould of the flat lands.

The intimate connection between geology and botany is here also strikingly exemplified, the partiality of *Eucalyptus albens* (a species of white box) for the Coal Measures affording an excellent means of identification from a distance; the pale bluish foliage of this species defining an almost clean line of demarcation between it and those darker-tinted varieties favouring the sterile Hawkesbury Sandstone.

As pointed out in a previous work,[1] there is no apparent stratigraphic break in the sequence of the Triassic and Permo-Carboniferous systems in the Western Coal-field, but palæontologically, the evidence of an intervening lapse of time during which sedimentation ceased, is emphasised by the differentiation and relative abundance of the fossil flora.

From the plentiful and well-preserved plant remains of the Coal Measures to the sparsely represented and commonly finely macerated flora of the Narrabeen, the transition is sudden and distinct.

One remarkable exception to the sudden break in palæontological continuity is afforded in the second Cremorne Bore, where immediately above the top coal seam, the Mesozoic fossil *Schizoneura* was found associated with the distinctively Permo-Carboniferous fern (in Australia) *Glossopteris.* Above this the former is abundant, but no trace of the latter has been found. The sudden extermination of *Glossopteris* evidences abrupt change of conditions of environment.

It has been found convenient to place the division between the Narrabeen and Permo-Carboniferous immediately above the top coal seam, though in places in the Southern Coal-field, according to Mr. Geological-Surveyor L. F. Harper, between Macquarie Pass and Mount Kembla, up to forty feet of shales containing *Glossopteris* occur *above* the coal.

At Victoria Pass, near Mount Victoria, in the Western Coal-field, Mr. H. G. Reinits informs the author he has found *Glossopteris* for some distance above the coal also. The Author was unable to personally confirm this, though the strata are evidently of a transitionary character.

An arbitrary base has also been fixed for the Upper Coal Measures at the Marangaroo conglomerate horizon. Beneath this bed marine conditions are indicated by magnesian and other salts effloresceing in sheltered positions, though definite evidence (fossils) are not noticeable until the lower division is reached.

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[1] Mem. Geol. Survey N. S. Wales, Geol., No. 3, 1903, p. 142.

The Marangaroo conglomerate is characteristically developed about Marangaroo, where it forms an escarpment traceable to Lithgow. It must, however, not be confounded with the marine quartzitic pebble conglomerates pierced in the Marangaroo railway tunnel. The *quartz* pebble bed, which forms the *summit* of the ridge over the tunnel, is the provisional base adopted for the Upper Coal Measures in the Western Coal-field.

In 1874–5, Mr. C. S. Wilkinson, F.G.S., F.L.S., Government Geologist, surveyed about one hundred and sixty square miles in the Bowenfels, Hartley, Wallerawang, and Rydal districts, producing the first geological map of that locality in the same year, which has been embodied in Sheet 12 of the present issue. Within this area are included all the coal-mines opened in the Western Coal-field, and the iron ore and limestone deposits once held by the Lithgow Valley Iron Company.

Mr. Wilkinson states that the locality was selected for survey by Mr. P. F. Adams, Surveyor-General, "as one wherein might be worked out the geological connection between the gold-bearing Silurian and Devonian rocks and the overlying Coal Measures."[1]

The Upper Coal Measures in the Western District were estimated by the same authority at about four hundred and eighty feet in thickness, resting conformably on the Upper Marine beds, and overlaid by about five hundred feet of the Hawkesbury series. In his map the latter were not separated from the Coal Measures.

As the Upper Coal Measures received considerable attention in the Author's Memoir on Kerosene Shale,[2] and are further dealt with in their economic aspect in another section of this work, it is proposed to treat only of western and north-western extensions of those Measures whose correlation was in doubt.

The farthest western coal outcrops—those of Ballimore on the Talbragar, about twenty-three miles north-east of Dubbo, and others along that stream—claim chief attention because of contemplated railway extension in that direction, and the possibility of saving about one hundred and eighty miles coal haulage to the Cobar smelters.

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[1] Ann. Rept. Dept. Mines for 1875, p. 115.

[2] Mem. Geol. Survey N. S. Wales, Geology, No. 3, 1903.

In connection with the latter statement, Warden Caswell, in 1885, recorded that a four and a half-inch coal-seam was cut in a Government drill-bore about half a mile from Dubbo, but no record of the boring is obtainable; also, that the Australian Diamond Drill Company had bored seven hundred feet, about five miles from Dubbo, without striking coal.[1]

Mr. E. F. Pittman, who examined the locality in 1880, reported:—"From Dubbo the road, *via* Cobborah, lies over Hawkesbury Sandstone, with overlying Pleistocene drift and patches of basalt. About Heane's station there are outcrops of what appear to be the true Coal Measures. These are well seen in section about six miles beyond Mr. Heane's, though I could find no fossils in them except some faint impressions of plant stems. From here to the Castlereagh, at Mundooran, the same description of country is met with, and there is no change as we proceed along the river to Gilgandra. . . . . . . The country between Dubbo and Castlereagh appears to be formed of a coal basin, the centre of which is situated a few miles north of Dubbo, and it is quite probable that the thin seams of coal seen in the cliff at Ballimore may overlie others of a payable nature."[2]

In a report on the Mudgee and Gulgong districts, Mr. Wilkinson stated definitely that:—"The Carboniferous formation with coal seams, extends from the Western Coal-fields of Lithgow and Wallerawang, past Rylstone and the head of Cooyal Creek, almost without a break to Tallawang, Spicer's Creek, Ballimore, and Dubbo."[3]

At a later date he modified his previous view, inasmuch, as he refers to the Ballimore beds as somewhat resembling in lithological character those of the Upper Coal Measures "to which they may belong," though the relationship of the *Glossopteris* beds, between Gulgong and Ballimore, had not been worked out.[4]

In 1888, Mr. Geological-Surveyor Anderson reported that—"From Dubbo eastward to Spicer's Creek, the country consists superficially of a coarse sandstone and conglomerate, which is covered locally by patches of Tertiary basalt, in some places overlying auriferous Tertiary drift. This grit and conglomerate, known as the Dubbo or Ballimore sandstone, lies horizontally, and shows false bedding. In a few positions, lenticular beds of thin-bedded shales, of no great extent, occur in it. It presents all the characters of the Hawkesbury Sandstone of the Blue Mountains, and there is little doubt that it is an outlier of that formation. . . . . Sections showing the relations between the coal-bearing strata and the overlying sandstone occur on the northern bank of the Talbragar River, at Ballimore Hill, for about a mile and a half up the river, and also in the north-west corner of the parish of Ballimore, about two miles above Gillies' accommodation house. On the north-eastern slope of Ballimore Hill, about one hundred feet of these coal-bearing beds are seen cropping out below the Dubbo or Hawkesbury Sandstone, while in the creek to the north of the hill about one hundred feet more of the beds are exposed. At the top of the hill, the Hawkesbury Sandstone is seen to rest on the underlying coal strata, with a slight unconformity, which, however, at this point, is hardly appreciable, the dip of the latter beds being not more than two or three degrees in a southerly direction."[1]

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[1] Ann. Rept. Dept. Mines N. S. Wales for 1885, p. 58.
[2] Ann. Rept. Dept. Mines N. S. Wales for 1880, p. 243.
[3] Ann. Rept. Dept. Mines N. S. Wales for 1886, p. 138.
[4] Ann. Rept. Dept. Mines N. S. Wales for 1887, p. 72.

Two diamond-drill bores were put down at Ballimore, No. 1 about a mile up the river from the hill. At five hundred and twenty-six feet, a seam of coal was struck, five feet three inches in thickness; at five hundred and fifty feet, artesian water was tapped ; one other coal seam was struck at six hundred and fifty-three feet, eleven inches thick. Total depth reached, seven hundred and ninety-four feet six inches.[2]

No. 2 bore was put down about sixty chains northerly from No. 1, to a depth of one thousand one hundred and one feet four inches. Thin coal seams were pierced at two hundred feet, and coaly layers at about six hundred feet, believed to represent the five feet three inches seam in No. 1 bore.

The depth, and occurrence of thick conglomerates, renders it more than probable that No. 2 bore penetrated the Coal Measures and entered the Upper Marine beds, in which case, anticipation of workable coal in the Talbragar basin is dissipated.

The most important fact in Mr. Anderson's report relates to the occurrence of *Glossopteris* at Spicer's Creek, about six miles from Ballimore, A shaft sunk in the creek, near the Wellington road crossing, to a depth of thirty feet, pierced "sandstone and light fireclay shales containing plant remains, chiefly rootlets and *Glossopteris* leaflets," overlying a four-foot coal seam, regarded as the probable representative of the Ballimore five feet three-inch seam.

At a later date, the same Author quoted the frequent occurrence or *Glossopteris* in the Dubbo and Talbragar coal-bearing beds as precluding correlation with the Clarence series.[3]

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[1] Ann. Rept. Dept. Mines N. S. Wales for 1888, p. 184.
[2] *Ibid.*, 184.
[3] Records Geol. Survey N. S. Wales 1889, I, page 139.

Mr. J. Mackenzie confirmed the presence of *Glossopteris* at Spicer's Creek crossing. In referring to a coal seam struck at a depth of fifty-seven feet, on Geurie Estate, he states :—" The coal seam evidently belongs to the same series as Ballimore and Spicer's Creek. At Spicer's Creek the same syndicate has sunk through a coal seam three feet eight inches in thickness, where I found *Glossopteris* and *Vertebraria* in shales immediately below it, thus showing that the Ballimore and Spicer's Creek Coal Measures are older than the Clarence River, and that they most probably belong to the Middle or Upper Newcastle Coal Measures, and those near Gunnedah."[1]

The Writer has recently confirmed the reported occurrence of *Glossopteris* in the spoil of the Spicer's Creek shaft, sunk a short distance from the creek, on the south bank. In the collection made by him, Mr. W. S. Dun has identified the following characteristic forms :—

Glossopteris Browniana.
,, *linearis.*
Vertebraria.
Phyllotheca australis.

From the conspicuous bluff on the Talbragar River bank, about half a mile below the Ballimore artesian bore, consisting of about fifty feet of Permo-Carboniferous Coal Measures, containing thin coal and kerosene shale seams above the river-bed, and about two hundred and fifty feet of Hawkesbury Series overlying the Coal Measures at the highest point, a suite of fossils were obtained, which have been determined by Mr. Dun as follows :—

Palæozoic Permo-Carboniferous (Upper Coal Measures).	*Walchia Milneana*	Tenison-Woods (probably a *Brachyphyllum*).	From a hard sandstone band close to river bed, intercalated between coal seams.
	Sphenopteris.	A form which appears to be close to *S. crebra*, and related to *S. lobifolia* of the Permo-Carboniferous of Newcastle, &c.	
	Sphenopteris ...	A species which may be Tenison-Wood's *S. glossophylla.*	

From higher up the Talbragar River, close to Meroutheree homestead, the writer obtained *Glossopteris Browniana* and *Noggeratheopsis Hislopi*, and indeterminable stems and leaves—Mesozoic,—from chocolate shales about eighty-five feet above the Coal Measures.

From somewhere in the neighbourhood, Mr. R. Etheridge, Curator, Australian Museum, has described *Blechnoxylon talbragarense*, associated with *Glossopteris* and *Brachyphyllum*.[2] This interesting plant is one of the ancient connecting links between cycads and ferns, classed by Potonié as Cycadofilices.[3]

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[1] Ann. Rept. Dept. Mines N. S. Wales for 1890, p. 193.
[2] Records Austr. Mus. III, No. 6, 1899, pp. 135-147.
Ibid., p. 142.

The Spicer's Creek Coal Measures are identical with those of Ballimore, and similarly overlaid by the Hawkesbury Series with typical chocolate shales.

Older Palæozoic rocks crop northerly about Leadville and Pine Ridge on the Talbragar, and southerly at Wellington, Geurie, and near Dubbo; thence westerly, a wide belt of granitic rock extends from Minore, giving place to Palæozoic slates about three miles from Narromine.. It is thus evident that a western prolongation of the Upper Coal Measures, extends towards the Castlereagh in the Ballimore trough. Beyond the Talbragar, however, the Writer has not had the privilege of investigating.[1]

The occurrence of true Permo-Carboniferous Coal Measures at Ballimore under typical, but thin, Hawkesbury Series, however, places the eastern boundary of the artesian area some distance west of that place, unless the Permo-Carboniferous be regarded as artesian on account of the Ballimore flowing bore therein.

The "Ginger-Beer" Spring in the Hawkesbury Series, close to the Merriwa-road, near Gungwall, evidently also arises from the underlying Upper Coal Measures. The pressure of the escaping gas imparts the appearance of strong ebullition to the pool in which it rises.

In addition to palæontological evidence of the age of the Ballimore Coal Measures, the occurrence of true kerosene shale is probably indicative of antiquity. Several thin seams, from half an inch to two inches in thickness, were noted in the coaly outcrops above the river-bed.

The following analyses reveal its quality, which, though inferior, shows a ratio of over two to one of volatile hydrocarbons to fixed carbon.

Proximate Analysis.

	No. 3,456.	No. 3,457.	No. 3,458.	No. 3,459.
Hygroscopic moisture ...	2·90	1·85	1·82	2·14
Volatile hydrocarbons ...	42·03	32·08	35·86	44·91
Fixed carbon	19·96	14·70	14·25	18·10
Ash	35·11	51·37	48·07	34·85
	100·00	100·00	100·00	100·00
Ratio of volatile hydrocarbon to fixed carbon ...	2·1 to 1	2·18 to 1	2·5 to 1	2·4 to 1

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[1] H. J. Jensen, B.Sc. Linnean Macleay Fellow, states:—"East, north-east, and south-east of the Warrumbungles, the formations are Permo-Carboniferous and Lower Trias, therefore non-artesian. North-west, west, and south-west the formations are mainly artesian Upper Triassic Strata."

In a foot-note Mr. Jensen remarks of the Triassic intake beds:—"I do not think any very definite evidence of age has so far been obtained, except that they cap the Permo-Carboniferous unconformably, and are of a fairly late Triassic age. They also seem to me to merge into the Cretaceous to the north-west of the Warrumbungles without any unconformity, but the point is doubtful." Proc. Linn. Soc., N.S. Wales, XXXII, No. 127, 1907, pp. 582–583.

Kerosene shale, of good quality, occurs in the same Measures at Ulan, on the Mudgee-Cassilis road, about ten miles from the Talbragar River.

The quality of the Spicer's Creek coal is shown in the following analysis of a sample selected by Mr. Anderson :—

4768–88—Hygroscopic moisture	3·60	Specific gravity	1·479
Volatile hydrocarbons	23·05	Sulphur	0·576 per cent.
Fixed carbon	54·65		
Ash	18·70		
	100·00		

No true coke; colour of ash almost white.

Mr. J. Mackenzie, Examiner of Coal-fields, visited the site the following year, and selected two samples, which, however, appear to have been picked from the best quality of coal only :—

	829–89 Upper portion of 3 ft. 8 in. seam.	830–89 Lower portion of 3 ft. 8 in. seam.
Hygroscopic moisture	5·65	7·44
Volatile hydrocarbons	36·60	27·86
Fixed carbon	45·35	54·10
Ash	12·40	10·60
	100·00	100·00
Sulphur	·727	·356
Specific gravity	1·330	1·422

No true coke.

CURLEWIS–GUNNEDAH, ON NORTH-WESTERN COAL-FIELD.

The Coal Measures of this field are identical with those of the Western, of which they are in fact a continuation northerly.

In the accompanying section fewer coal seams are noted, but others may exist where *débris* obscures the natural section.

The dip of the working seam at Black Jack Colliery, near Gunnedah, is south-west at about one in twenty-one. At the Centenary Colliery, Curlewis, the main dip is also south-westerly, but the presence of a dyke has caused local variations. The same seam is worked in each. The seam contains five to six feet of bright bituminous coal, the quality of which at both collieries is seen in the following analyses recorded by E. F. Pittman :—[1]

	Centenary Colliery, Curlewis.	Gunnedah Colliery, Black Jack.
Hygroscopic moisture	2·40	2·55
Volatile hydrocarbons	33·30	35·35
Fixed carbon	56·30	55·35
Ash	8 00	6·75
	100·00	100·00
Sulphur	·453	·508
Specific gravity	1·378	1·360
Coke	64·30*	62·10†
Lb. of water converted into steam by one lb. of this coal	12·	12·3

*Coke, moderately swollen, bright and firm; ash white and granular. † Coke, not much swollen, hard and dull; ash greyish, part granular, part flocculent.

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[1] Mineral Resources, New South Wales, 1901, pp. 327, 329.

Recent average samples of the seam and overlying Carbonaceous Shale at the Centenary Colliery yielded the following results:—

	No. 5,436 (seam).	No. 5437 (roof).
Hygroscopic moisture	1·55	1·23
Volatile hydrocarbons	34·08	14·21
Fixed Carbon	53·74*	43·11
Ash	10·63*	41·45
	100·00	100·00

*Coke, 64·47 per cent., well swollen, firm and lustrous; ash, grey in colour, semi-granular; sulphur in coal, 0·494 per cent.; specific gravity, 1·357; calorific power, 12·1.

The sandstone roof of the lowest or Lithgow seam of the Western Coal-field, which usually contains pebbles at its base, but occasionally, as at Blackman's Flat, becomes wholly conglomeratic, at Curlewis and Black Jack is conspicuously developed into conglomerate of quartz-pebble character, which distinguishes it from the jasperoid and chalcedonic conglomerates strongly in evidence in the overlying Hawkesbury Series.

At first sight it appears to be the Marangaroo which forms such a convenient base for the productive Coal Measures in the Western Coal-field. There is, however, little doubt that the Lithgow and Curlewis-Gunnedah main seams are identical; and that the roof conglomerate has usurped the prominence of the underlying Marangaroo of the Western field.

If not, the apparent failure of a notable Western seam must here be recorded, coincident with development to workable proportions of one but faintly represented.

The main seam at Curlewis and Gunnedah occurs about twenty-five feet below the quartz-pebble conglomerate forming a marked escarpment; whilst the main Lithgow seam occurs immediately above the most conspicuous conglomerate bed—the Marangaroo.

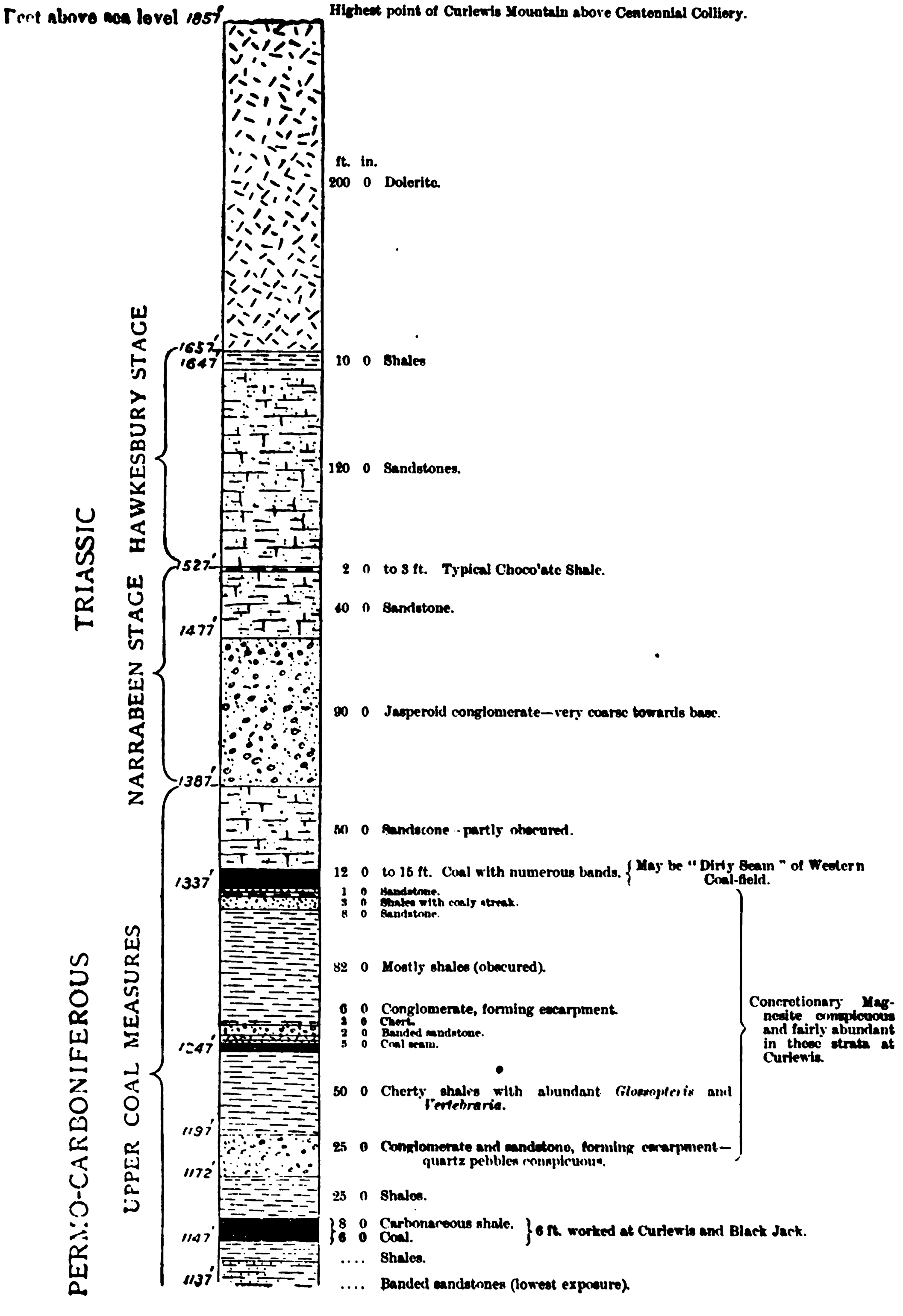
In the Grose and Capertee Valleys, a few inches of coal occur both above and below a marked conglomerate, which may represent the horizons of both seams as separate entities.

The upper beds of the Coal Measures, like those of the West, are chiefly of a cherty character so far as examination has revealed.

Similar cherts occur in the Newcastle Coal-field, where they have been identified by Professor David as fine felspar tuffs.

GUNNEDAH-CURLEWIS COAL-FIELD.

Fig. 3—Section of Upper Coal Measures at Curlewis Mountain.


Feet above sea level 1857'
Highest point of Curlewis Mountain above Centennial Colliery.
ft. in.
200 0 Dolerite.
1657'
1647'
10 0 Shales
120 0 Sandstones.
1527'
2 0 to 3 ft. Typical Chocolate Shale.
40 0 Sandstone.
1477'
90 0 Jasperoid conglomerate—very coarse towards base.
1387'
50 0 Sandstone—partly obscured.
12 0 to 15 ft. Coal with numerous bands. { May be "Dirty Seam" of Western Coal-field.
1337'
1 0 Sandstone.
3 0 Shales with coaly streak.
8 0 Sandstone.
82 0 Mostly shales (obscured).
6 0 Conglomerate, forming escarpment.
1 0 Chert.
2 0 Banded sandstone.
5 0 Coal seam.
1247'
50 0 Cherty shales with abundant *Glossopteris* and *Vertebraria*.
1197'
25 0 Conglomerate and sandstone, forming escarpment—quartz pebbles conspicuous.
1172'
25 0 Shales.
Concretionary Magnesite conspicuous and fairly abundant in these strata at Curlewis.
8 0 Carbonaceous shale.
6 0 Coal.
6 ft. worked at Curlewis and Black Jack.
1147'
.... Shales.
1137'
.... Banded sandstones (lowest exposure).
TRIASSIC
HAWKESBURY STAGE
NARRABEEN STAGE
PERMO-CARBONIFEROUS
UPPER COAL MEASURES

The Hawkesbury Series, overlying the North-western Coal Measures, can be traced continuously from the Hunter River Valley about Denman, in cliff escarpments, to Murrurundi, and thence to Curlewis and Gunnedah, beyond which point the Author has not followed them. From Denman to Murrurundi, they do not appear east of the Great Northern railway. The latter, however, passes west of their eastern margin, after traversing the Murrurundi tunnel at Ardglen. The most distant exposures examined in this direction occur on the slopes of Mount Temi, above the Doughboy Hollow kerosene shale deposit.

A special feature of the northerly extension of this series is the gradual passage of shaly Narrabeen Beds of the Metropolitan area into conglomerates of increasing coarseness, indicating direction of transport.

Between the Hawkesbury and Hunter, and in the watershed of the Goulburn, the change becomes apparent.

At Murrurundi, a thickness of about two hundred feet of these conglomerates is exposed in cliff sections; above these again, about one hundred feet of sandstone where best preserved; and over the latter, dolerite. From ninety to one hundred feet of conglomerates occur above the Coal Measures at Curlewis and Gunnedah. At the former, about one hundred and sixty feet of sandstones overlie the conglomerates, and are in turn overlaid by two hundred feet of dolerite.

Here, also, the chocolate shales are typically developed about forty feet above the conglomerates, and, doubtless, can be traced wherever denudation has spared the sandstones.

The special features of these conglomerates are the chalcedonic and jasperoid constitution of the boulders and pebbles. Red and green are the predominant colours, whilst ordinary white quartz pebbles are rarer and smaller. The basal deposit is coarse, enclosing boulders exceeding a foot in greatest measurement.

It is probable that these characteristic conglomerates have been derived from the great series of highly altered Carboniferous or Devonian sedimentaries (containing *Lepidodendron*) now exposed along the Isis River. In the latter stream channel, excellent sections occur, consisting of red and green jasperoid rocks, intercalated with quartzites and massive conglomerates.

Upper Coal Measure Fossils.

Plants.

Forms common to each of the coal-fields in the Upper Coal Measures. The following have been figured from the Western District:—

Glossopteris comp. *angustifolia*, Bgt., Blackman's Swamp
„ *Browniana*, Bgt., Blackman's Swamp and Bowenfels
„ *communis*, Feistm., Bowenfels
„ *tæniopteroides*, Feistm., Blackman's Swamp
„ *paralella*, Feistm., Bowenfels
„ *linearis*, M'Coy, „
„ *Wilkinsoni*, Feistm., Blackman's Swamp
„ *gangamopteroides*, Feistm., Bowenfels
„ *spathulata-cordata*, Feistm., „
Gangamopteris Clarkei, Feistm., „
Noggerathiopsis media, Dana., „
Vertebraria australis, M'Coy „
Brachyllum (?) *australis*, Feistm., „

Mem. Geol. Survey
N. S. Wales,
Pal. 3, 1890.

Vertebrata.

A fish from the Upper Coal Measures at Lithgow is now under reference to Dr. Smith Woodward, Keeper of Geology, Natural History Museum, St. Kensington, the only previous discovery being ***Urosthenes australis***, Dana., from Newcastle.[1]

A portion of vertebra and ribbing of a *Labyrinthodont* has recently been discovered in the kerosene shale deposit at Airly (Genowlan), and is now being described by Dr. Woodward.

Permo-Carboniferous—Upper Marine Beds.

The Upper Marine Beds are extensively developed below and beyond the margin of the productive Coal Measures. They lie unconformably on Devonian Sedimentaries; and, in places, on Post-Devonian granite and quartz-felsite intrusives.

The following description from the recently-issued "Memoir on Kerosene Shale Deposits,"[2] by the Author, summarises the chief points of interest:—

"They consist of massive basal conglomerates and soft, sandy, clay shales, with several intercalated thick beds of sandstone, which, from superior resistance to weathering, and the undermining action of the lower shales, escarp in strong relief where this formation is exposed in the valley slopes.

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[1] Am. Journ. Sci., 1848 (2), v, pp. 433–434.

[2] Memoirs Geol. Survey N.S.W.—Geol. 3, 1903, pp. 125–129.

"The Marine Series rest unconformably upon the folded Devonian rocks for the most part. The basal conglomerates are of great thickness, and of increasing coarseness towards the lowest stratum, which consists of a jumble of great boulders in a cement of sand.

"The petrological character and structural arrangement of this great bed indicate unmistakable marginal deposition or proximity of the coast-line of the Permo-Carboniferous sea.

"Just as clearly, also, do these sediments denote the source from which they have been derived. The boulders and pebbles are chiefly quartzite, and, more rarely, granite, porphyry, and slate.

"If further confirmation of their derivation from the underlying Devonian System were necessary, frequent boulders and pebbles bear imprints and casts of characteristic fossils of that period.

"The most puzzling feature of the conglomerates is the occurrence in them at all levels, and frequently many miles from the ancient coastal margin, of huge boulders of quartzite embedded in a cement of sand or fine conglomerate, usually subangular, showing abrasion, and weighing up to several tons.

"Throughout the conglomerates, though broad lines of sedimentation exist, becoming more pronounced in ascending order from their base, there appear frequent jumbling and disordering of the regular sequence beyond the natural disturbance expected from coastal currents and shore eddies. Nor is it conceivable that river effluence could bear huge blocks far beyond the margin of the sea, where the hydraulic power of the stream would soon be lost. Nor yet that receding tides could drag them into the positions they occupy.

"One power alone seems adequate, and yet diligent search through miles of natural and artificial sections, and over large surface areas, has failed to furnish confirmatory evidence. Icebergs breaking from the coast and bearing burdens of rock out to sea, dropping them one by one amongst the finer sediments wave-borne farthest from the shore, as the bergs split up or melted. Such would seem a satisfactory solution of the problem, but for the fact that no direct evidence of glaciation has been seen."

Professor W. J. Stephens, writing, in 1882, of the coarse conglomerates in the vicinity of Capertee, states :—

"But many of the blocks are of very large size, five or six feet in diameter, and are nevertheless mixed up like plums in a pudding with the finer grained matrix in which they lie. Some of these, as notably near Stone House, two miles north of Capertee, are finely polished (as are also fragments of hard conglomerate near Round Swamp); but there is, so far as I could see, no positive evidence of glacial striation, nor does the character of the polish connect it with glacial action. Nevertheless, I feel assured that no other agency than that of great mountain glaciers, feeding strong watercourses, which were also subject to violent but occasional floods, as at the melting of superficial snows in spring, could ever have piled up, or, rather, spread out, the coarse alluviums of which I write." [1]

Professor David states that the late Government Geologist, Mr. C. S. Wilkinson, regarded the coarse marine conglomerates of the Lower Coal Measures, near Wallerawang, in the Western Coal-field, containing large smooth blocks of Devonian quartzite, as probably of glacial origin.[2]

Granite erratics have been described by Professor David, in the Upper Marine Beds of the Permo-Carboniferous near Branxton, in the Hunter River district,[3] which, unlike the isolated blocks of the Capertee Valley, have been transported far from the parent rock. A facetted and glacially striated pebble was discovered here in 1898 by W. G. Woolnough, D.Sc.,[4] which furnishes direct proof of Permo-Carboniferous glaciation, as first intimated by R. D. Oldham in 1885,[5] and afterwards confirmed by Professor David in 1887.[6]

It is, therefore, more than probable that similar evidence may yet be found in this formation in the valley of the Capertee. Possibly, freshly denuded surfaces of the Devonian rocks, beneath the Marine beds, may yet furnish instances of glaciated floors. Near Lochinvar an important glacial horizon was discovered by Professor David and others in 1898, at the base of the Permo-Carboniferous System.[7]

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[1] Notes on Geol. of the Western Coal-fields : Proc. Linn. Soc. N.S.Wales, 1882-3, pp. 548-555.
[2] Quart. Journ. Geol. Soc., 1887, XLIII, p. 193.
[3] Rept. Austr. Assoc. Adv. Sci., 1895, VI, p. 70.
[4] Journ. R. Soc. N. S. Wales for 1899, XXXIII, p. 156.
[5] Records Geol. Survey India, 1885, XIX, Pt. I, p. 44.
[6] Quart. Journ. Geol. Soc., 1887, XLIII, pp. 190-196.
[7] *Op. cit.*, p. 156.

It is interesting to note that a corresponding geological horizon in Northern Queensland affords similar evidence to that of the Capertee Valley. Messrs. Jack and Etheridge, in describing the Middle Bowen Formation, make the following statement:—"A few beds of conglomerate are met with in the lower part of the series. The pebbles are generally of granite, slate, schist, quartzite, and other metamorphic and plutonic rocks, with a few of porphyrite. The pebbles, which are not always well rounded, have a remarkable tendency to arrange themselves in groups in some of the conglomeratic sandstone beds, a disposition which may possibly be owing to their having been dropped in heaps from the floating roots of trees, but more likely to their having been dropped from floating ground ice. Large isolated boulders of granite, &c., which could hardly have been brought into their present positions except by glacial action, occur here and there in the midst of strata of fine sandy or muddy material."[1]

Where denudation has been extreme, the hard quartzitic boulders and pebbles of the Marine conglomerates alone remain as a loose capping on the Devonian ridges, closely imitating, and frequently being mistaken for, terraces of ordinary alluvial and channel drifts.

Above the thick basal conglomerate, shales, sandstones, and conglomerates alternate; the shaly character predominating in the uppermost beds.

The effect of weathering varies with the character of the strata, the conglomerates simulating drifts, the sandstones forming scarped terraces on the slopes of the crumbling shales, or level platforms capping denuded hills. Where thus exposed, a most pronounced concentric structure is developed.

In isolated hummocks or tapering ridges of the shales, a peculiar and misleading appearance results from weathering, most clearly seen in railway cuttings west of Capertee. The horizontal bedding planes of the central mass as they approach the sides appear to be sharply folded or faulted down. Similar phenomena occur in the Wianamatta shales, which at first were attributed to shrinkage folding, but subsequently regarded as due to expansion.[2] The Capertee instances are solely due to breaking down or deflection by weathering.

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[1] Geol. and Pal. of Queensland and New Guinea, 1892, pp. 150-151.

[2] Journ. R. Soc. N. S. Wales for 1896, XXX, p 54.

Thin bands of fine-grained, buff-coloured dolomite occur in the uppermost beds of the series, and, from the rich chrome yellow colour assumed in weathering, form an excellent guide to the geological horizon when other evidence is wanting. Its composition may be judged from the following analysis, by J. C. H. Mingaye, of a sample selected from Green Hills, close to Glen Alice homestead :—

00-4,174—	Moisture at 100° C.	·70
	Combined water	3·05
	Silica	8·56
	Alumina	7·03
	Manganous oxide	trace.
	Ferrous carbonate	8·88
	Ferric oxide	2·73
	Calcium carbonate	42·49
	Magnesium carbonate	25·49
	Potash	·90
	Soda	·21
	Phosphoric acid	·22
	Titanic acid	trace.
	Sulphuric acid	nil.
		100·26

In the parish of Burrumbelong, eastward of the Barigan kerosene shale deposit, an earthy limestone, with radiating concretionary arragonite, forms the top stratum of the Upper Marine Series, immediately underlying the Marangaroo conglomerates, whilst itself overlying a thin sill of basalt. Professor David has noted an almost similar occurrence of limestone at the top of the same series at Mount Vincent, in the Hunter River Valley. The soil resulting from this rock simulates that derived from decomposing volcanic rocks.

Viewed over large areas, the more clayey nature, and deeper and more ferruginous colours of the surface soils of the Upper Marine strata, differentiate them from those of the overlying fresh-water Coal Measures, which usually furnish lighter-coloured and more shaly soils.

UPPER MARINE SERIES.

Palæontology.

Unlike their equivalents of the Hunter River and Southern Coal-fields, the Upper Marine Beds of the Western Coal-field are singularly destitute throughout their greatest vertical extent of fossiliferous remains of the life of the period. The Author's experience coincides with that of Professor

Stephens[1] in finding them only in the lowest stratum—a coarse conglomerate, resting directly on the Devonian. Probably the great influx of sand, mud, and boulders which ensued rendered life conditions unfavourable.

The following forms from the district have been identified by Mr. W. S. Dun. :—

Martiniopsis subradiata, G. B. Sby.	Near Mount Stewart, parish Goollooinboin, county Cook.
Spirifer vespertilio, G. B. Sby.	
Spirifer tasmaniensis, G. B. Sby.	
Productus brachythærus, G. B. Sby.	
Mæonia, sp.	
Strophalosia Clarkei, Eth.	Capertee Valley.
Conularia inornata, Dana	

In a previous collection by the Author, Mr. R. Etheridge identified, in addition to several of the above forms, *Goniatites* or *Bellerophon* and *Fenestella*, from about thirty chains west of north-west corner of portion 80, parish Goollooinboin, county Cook.[2]

Mr. Wilkinson records, in Note 17 on the Geological Map of Bowenfels, &c., *Spirifer vespertilio*, *Spirifera*, *Productus*, *Euomphalus*, *Pecten*, *Counlaria*, &c., in a bed of ferruginous conglomerate about thirty chains east-south-east of Marangaroo railway platform.

DEVONIAN.

Devonian rocks are exposed on the margin of the Permo-Carboniferous in Sheets 12 and 13. The most extensive development is shown in section between Mount Lambie and Lithgow, on Sheet 12. Mr. C. S. Wilkinson (from whose map of the district this portion is taken), referred to it in the following terms :—"A fine section of the Devonian Beds is seen near Rydal, on the Great Western railway. This section has been measured by myself, and shows a thickness of not less than ten thousand feet. The lower beds, which form the summit of Mount Walker and Mount Lambie, consist of sandstones and quartzites, with numerous fossils, chiefly *Spirifer disjunctus*, and *Rhynchonella pleurodon*; while above these are shales, slates, and quartzites, containing *Lepidodendron nothum*."

"Rocks of this age occur also on the Cudgegong and Turon Rivers, and in the Wolgan Valley."[3]

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[1] Proc. Linn. Soc., N.S.W., 1882-3, VII, pp. 548-555.
[2] Records Geol. Survey N. S. Wales, IV, 1894, p. 48.
[3] Min Prod. N. S. Wales, 2nd ed., 1887, p. 57.

Professor David and Mr. E. F. Pittman discussed the stratigraphical and geological horizons of Lepidodendron at Mount Lambie and elsewhere, their conclusions being that *L. australe* (which is the original type of *L. nothum*) occurs at Mount Lambie in Upper Devonian rocks associated with marine fossils, such as *Spirifer disjuncta* and *Rhynchonella pleurodon.*[1]

It may be noted that *Lepidodendron*—one of the most characteristic of old-world coal fossils—occurs beneath the productive Coal Measures in Australia, where it ranges from Upper Devonian to Carboniferous.

Though a few thin inferior coal seams occur in the Stroud Division of the Carboniferous of this State, it is only in the overlying strata associated with a blending of Permian and Carboniferous fossils that workable coal seams are developed.

The association of *Lepidodendron* with *Spirifer disjuncta* at Mount Lambie, establishes the Devonian age of the former; whereas its association with *Rhynchonella pleurodon* only, at Sugarloaf Mountain, in the Braidwood district, is not so conclusive, because of the greater range of the latter.

The following fossils have been recorded from Mount Lambie:—

Rhynchonella pleurodon.
Spirifer disjuncta.
Pteronites Pittmani.
Leptodomus.
Aviculopecten.
Loxonema.
Chonetes.
Crinoid Stems.
Lepidodendron australe.

The following occurrences are recorded on Mr. Wilkinson's map of the district:—" Note 10. In road cutting south-east of Mount Lambie are thin-bedded white siliceous sandstones and light brown shales (dip E. 25 S. at 35) full of Devonian Brachiopoda, Spirifera, Rhynchonella, &c."

" Note 11. Solitary Creek, near Fern Grove. Thin-bedded sandstones and sandy shales (dip S. 35 E. at 10), full of Devonian Mollusca, Spirifer, Rhynchonella, Pecten, Orthis, Murchisonia, Modiola, Corals, and Encrinite Stems."

" Note 27. Between Gaden's and Thompson's Creeks. Sandstones and shales containing Trilobites, Corals, &c."

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[1] Records Geol. Surv. N. S. Wales, 1893, III, Pt. IV, pp. 194–201.

In the Portland limestone Mr. Wilkinson recorded in "Note A" the presence of *Favosites gothlandica, F. polymorpha, Lithostrotion,* and others; and Molluscs as yet undetermined.

From the Capertee Valley the following forms have been previously recorded by the Author.[1] :—

Favosites gothlandica.
„ small-pored form, probably undescribed.
Cyathophyllum.
Stromotopora.
Heliolites, new species, dendroid form.
Fenestella.
Syringopora, three species.
Athyris.
Amphipora.
Murchisonia.
Gasteropoda, indeterminable.
Spirifera disjuncta.
Spirifera, small species of the *S. Jaqueti,* Dun, type, but differing in possessing more numerous and delicate costæ.
Spirifera, medium-sized species of the type of *S. Oweni,* Hall.
Spirifera, a new species, large form, very deep and fine-ribbed, plain sulcus, slightly winged.
Nuculana sp.

Recently Mr. W. S. Dun identified Radiolaria in a rock specimen collected by Mr. M. Morrison, at the south-west corner of Portion 17, Parish Falnash, County Roxburgh, which he described in the following terms:—

"This rock is fine-grained, and contains siliceous casts of Radiolaria in considerable numbers. The forms are apparently referable to the Spheroidea and several forms with double medullary rings and axial spines (traces) are seen.

"Of the general type of the Tamworth radiolaria (Spheroidea)."

The Devonian strata in pre-Permo-Carboniferous time were intruded by granite and quartz porphyry where the valleys of the Cox and Capertee are now situated, at Rylstone and Camboon, and to a slight extent in the Upper Wolgan Valley; also by diorite close to Ben Bullen, on the west.

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[1] Mem. Geol. Survey N. S. Wales, Geol. 3, 1903, p. 125.

No instances of later intrusions of these rocks have been noted in the areas mapped, though, as previously pointed out, the Permo-Carboniferous have been intruded by plutonic rocks in New England, and at Camden Haven.

The granitic and porphyritic intrusions of the Western Coal-field elevated the Devonian Beds in huge folds, excellent sections of which—both anticlinal and synclinal—are exposed in the stream channels of the localities mentioned. An enormous lapse of time is represented stratigraphically and palæontologically between the folding of these strata and deposition of the succeeding. On the truncated surfaces of the huge puckers rest the coarse basal beds of the Upper Marine Series, made up almost entirely of the waste of the former.

Overlap, as well as unconformity, is here indicated. In the centre of the great Permo-Carboniferous coal basin of the Hunter River Valley, all the missing members of the geological record between are represented in an estimated thickness of about nineteen thousand feet, including J. B. Jaquet's estimate of Stroud Carboniferous rocks.

In the accompanying section, showing relative positions and stratigraphy of the Northern, Southern, and Western Coal-fields, the complete sequence of the productive Coal Measures in New South Wales is shown (after Professor David).

The entire thickness of Permo-Carboniferous strata in the Western coal areas mapped, probably does not exceed 600 feet.

Geology and Botany.

The influence of geological conditions on botany is so pronounced and distinctive in insular areas on the sandstone plateau as to arrest attention even of those unfamiliar with the cause; hence local nomenclature, based on forest differentiation, is frequently indicative of geological or petrological change.

Certain botanic genera and species evidently require or favour special fertilising elements for their germination and proper development, such as only particular kinds of rocks afford in appreciable quantities as they decompose into soils. Botany thus becomes an index to geology and *vice versâ*.

On a comparatively sterile sandstone plateau like the Blue Mountains, with stunted scrubby forest growths, the botanical change in small isolated patches of rich volcanic soil, is emphasised by luxuriance, and generic and specific distinctions.

Remnants of once widespread lava-flows, or extensive crater-necks, form veritable oases in a comparative desert of sandrock, and afford some idea of the splendid compensation the original lava-sheets would have been for so much sterility. In this case it has not been survival of the fittest in the restricted sense of human requirement.

The pure sandrock of the plateau, though more liable to mechanical weathering stress, contains fewer elements of chemical weakness than the basic lava, whose decomposition affords the rich loamy soils supporting luxuriant vegetation.

Isolated and difficult of access though many of them be, enterprising settlers have utilised the rich pasturage of several of them in times of drought. One of the most isolated masses—Mount Uraterer--was the home of a solitary settler for many years, every necessary the soil did not yield being conveyed on horseback over a rugged, devious bridle-track; even the essential plough being thus conveyed in parts.

Alan Cunningham,[1] writing of Mount Tomah, says:—"The soil of these shades is a fat argillaceous loam, blended with much decomposed vegetable matter. In this earth I remarked, partially buried, large blocks of compact whinstone (basalt.—J.E.C.) in no regular form. . . . . . . Upon entering the forest, the traveller is struck with the change in the appearance of the timbers from the *Eucalypti* of the open country, the stupendous size and extraordinary windings of the climbers, particularly *Cissus*, and with the magnificence of the tree-ferns, *Dicksonia antarctica*, some of which were thirty feet in height and six to fourteen feet in diameter. In truth, all the striking change to tropical scenery meets the eye, which appears so remarkable at the mountain top above the Five Islands" (Illawarra.—J.E.C.)."

The volcanic phenomena of the Blue Mountains received scant notice from early explorers, though the luxuriant associated vegetation compelled attention.

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[1] Hooker's Journal of Botany, 1842, IV, pp. 285-6.

Surveyor Dickson, in 1830, and Surveyor Govett, in 1831, were the first to ascend Mount Hay, and the latter to delineate its topography, and and that of Tomah, Bell, Mount Banks (or King George), and Wilson. Strangely enough, whilst struck with the "peculiar vegetation," both failed to note the difference in the associated summit rocks, after the monotony of the plateau sandstone.

P. N. Trebeck, in his description of the ferns of Mount Wilson,[1] mentions the sudden transformation from the ordinary dull, brown, stunted gums to the most luxuriant growth of sassafras, mimosas, acacias, tree and other ferns, and numerous other dark and bright green handsome shrubs, as the traveller passes from sandstone to basaltic soil.

After noting the "scanty and miserably stunted and gnarled timber" of the sandstone formation, E. Du Faur[2] describes the approach to Mount Wilson thus:—"The denser undergrowth, the increased size and improved symmetry of the trees, and the rich black soil beneath his feet, tell of a sudden change. A few yards further on, along a rather steep ascent of about one in seven, is disclosed a charming avenue cut through this dense undergrowth, on a steep sidling bordered with clematis, wild tobacco plants, native raspberry, and other luxuriant shrubs, amongst which tower lofty blue gums (*Eucalyptus botryoides*), stringybark (*E. amygdalina*), blackbutt (*E. pilularis*), and other eucalypti, interspersed with clumps of sassafras (*Doryophora sassafras*), acacias, and tree-ferns (*Alsophila australis* and *Dicksonia antarctica*) of an unusual height. The cause of this sudden change is at once apparent. The upper bank of the road is studded with boulders of basaltic rock, a dyke of which has burst through and overcapped the sandstone, and its disintegration has formed the rich black chocolate-coloured soil which has favoured this special vegetation."

An early explorer—Captain C. Sturt—has recorded his impressions of the intimate connection of geology and botany over a wider area[3]:—"Whilst prosecuting my researches into the interior of the Colony, I could not but be struck with the apparent connection between its geology and vegetation; so strong, indeed, was this connection that I had little difficulty, after a short experience, in judging of the rock that formed the basis of the country over which I was travelling from the kind of tree or herbage that flourished in the soil above it. The *Eucalyptus pulv.*, a species of eucalypt having a glaucus leaf, of dwarfish habits, and growing mostly in scrub, betrayed the sandstone formation wherever it existed. This was the case in many parts of the county of Cumberland, in some parts of Wombat Brush, at the two passes on the Great South road, over a great extent of country to the north-west of Yass Plains, and at Blackheath, on the summit of the Blue Mountains. On the other hand, those open grassy and park-like tracts, of which so much has been said, characterise the secondary ranges of granite and porphyry. The trees most usual in these tracts were the box, an unnamed species of eucalyptus, and the grass chiefly of that kind called the oat or forest grass, which grows in tufts at considerable distances from each other, and which generally afford good pasturage.

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[1] Proc. Linn. Soc. N.S.Wales, 1886, I (2), Part II, pp. 491-2.
[2] Railway Guide, N.S.Wales, 3rd ed., 1886, p. 64.
[3] Two Expeditions into the Interior of Southern Australia, 1828-1831, I, pp. XXX-XXXII.

"On the richer grounds *Angophora lanceolata*[1] and *Eucalyptus mannifera* more frequently point out the quality of the soil on which they grow. The first are abundant on the alluvial flats of the Nepean, the Hawkesbury, and the Hunter; the latter on the limestone formation of Wellington Valley, and in the better portions of Argyle; whilst *Cupressus calytris* seems to occupy sandy ridges with the Casuarina. It was impossible that these broad features should have escaped observation. It was naturally inferred from this that the trees of New South Wales are gregarious; and, in fact, they may in a great measure be considered so. The strong line that occasionally separates different species, and the sudden manner in which several species are lost at one point, to reappear at another more distant, without any visible cause for the break that has taken place, will furnish a number of interesting facts in the botany of New South Wales."

In the Author's experience, connected with geological mapping of the Western Coal Measures, the value of botany as a guide to geology has often been strikingly exemplified, more particularly where the latter has been obscured by transported débris.

In the interesting volcanic centres of Kelgoola and Putty, where numerous truncated crater necks occur, botany reveals their existence, in spite of superficial cover. Even where the contact rim-rock has—like the neck—been reduced to common valley level, and outlines and soil distinctions obliterated, the deep-rooted forestry betrays the secret of its presence and luxuriance.

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[1] Probably *Angophora intermedia.*—J.E.C.

In the Kelgoola district, ***Eucalyptus melliodora*** (yellow box) almost invariably flourishes within the circumscribed limits of the necks in the low denuded areas, to the total exclusion of the stringybark (*E. eugenioides*) and other hardier denizens of the surrounding sterile sandy soil. The botanic boundaries of these insular habitats of *E. melliodora* are so marked and so distinct as to appeal to the observant bushman unacquainted with either botany or geology.

Mr. John Davis, of Ginghi, a native of the locality (to whose intelligent guidance the Writer is greatly indebted), when the geological significance was explained, readily located numerous "yellow box forests," for which he had specific local names. These invariably proved volcanic necks, and search usually disclosed corroborative geological evidence.

In fewer instances a variety of white gum (*E. viminalis* ?) is equally distinctive in the circumstances described; but this species is more characteristic of volcanic soils at greater altitudes, where *E. melliodora* is absent.

In the Putty district, local nomenclature is indicative of botanical and physiographical distinctions. "Clears" denote circular hollows, with open forestry and luxuriant pasturage, such as distinguish volcanic necks from the denser, dwarfed, forest growths, and scanty wire grasses of the prevailing sandstone country.

Frequently streams heading in volcanic necks have sawn through encircling precipitous cliffs, producing a resemblance to frying-pans with long crooked handles; such are discriminated as "round-topped arms," arm being synonymous with creek or stream.

"Holes" are also suggestive appellations for the circular heads of those channels.

To the occurrence of such phenomena and lava streams the fertility of the restricted Putty valleys is due.

The botany of the "clears" and "basalt masses" of this district has received attention from Mr. A. C. Barwick,[1] who states that, on approaching the "clears," "one is at once struck by the marked difference between the growth of the vegetation on it and on the adjacent sandstone country, and by the absence on the volcanic soil of species growing in profusion on the sandstone, as well as by the comparative rarity of a certain species of Eucalyptus on the sandstone which is always present in the "clears," *i.e., E. hemiphloia,* F.v.M." (the coastal variety of white box.—J.E.C.).

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[1] Proc. Linn. Soc. N.S.Wales, 1903, XVIII, Pt. 4, pp. 932-943.

The local names, "Box Bump" and "Boxy Clear," are based on the occurrence of this species.

The absence in Mr. Barwick's census of jungle vegetation commonly associated with Blue Mountain volcanic rocks, further south, will be remarked. Inferior elevation, and consequent lessened rarification of moisture-laden air currents, are accountable for its non-existence; just as rarification and concomitant precipitation are for its presence on the eastern or coastal fronts of the highest peaks and ranges. Conversely, the latter causes explain the conspicuous difference between the vegetation of the eastern and western slopes of the greatest elevations; a difference noticeable even on the summits. Dry westerly winds from the interior are also potent factors in the result.

The Putty "clears" and basalt masses occur in a comparatively flat extension of the plateau which does not present a conspicuous eastern or sea front to influence air currents and vegetation.

The eastern faces of Tomah, Wilson, Coricudgy, Coriaday, Monundilla, and other prominent basalt peaks, are clothed with ordinary coastal-range jungle, of which sassafras (*Doryophora sassafras*), coach-wood (*Ceratopetalum apetalum*), tree-ferns (*Dicksonia antarctica, Alsophila australis*), and others, are representative.

On the summits huge eucalypts flourish. *E. viminalis* and *E. amygdalina* crown the tops and western slopes of Coricudgy, Coriaday, Monundilla, and many others, where neither jungle nor undergrowth exist.

A. G. Hamilton[1] states that, of twelve species of eucalypt at Mount Wilson, two only (*E. viminalis* and *E. amygdalina*) are found on the basalt.

The same authority's investigation of rain records led him to the conclusion that the wealth of Mount Wilson flora was entirely due to its rich volcanic soil. This may be true of equal altitudes, but aspect and moisture must also influence results. Mists and heavy dews are more frequent on the higher points.

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[1] Proc. Linn. Soc. N.S.Wales, 1899, XXV, Pt. 3, p. 349.

Further west, within the area extending north of Sheet 18 botany, even from a distance, affords an unerring clue to radical change in prevalent geology. Huge laccolithic mountains of nepheline-ægerine (tinguaite), raising domed summits above the intruded plateau sandstone, in vegetation, no less than configuration, offer forcible contrast to their surroundings.

Less liable to decomposition, and yielding less fertile soils than the basalt peaks, paucity, rather than affluence, characterises their flora. Here, again, local nomenclature signalises special distinctions. The treeless, spinnifex-clothed summits of some suggested the frequent "bald" Mountains; whilst the predominant "she-oak" (*Casuarina stricta*) gave rise to the common appellation of "Oakeys."

Recently, R. H. Cambage, L.S., in a thoughtful paper,[1] has endeavoured to account for the insular occurrence of this particular species on the Narrabeen shales at Otford and Newport on the coast, on geological grounds—*i e.*, its partiality for this formation. Its apparent restriction to the very limited outcrops of Narrabeen shales at these localities has suggested survival from geologically recent greater coastal extension of this formation.

The partiality of *Eucalyptus albens* (a variety of white box) for the Coal Measures in the Bylong and other western valleys affords an excellent means of identification from a distance, the pale-bluish foliage of this species defining an almost clean line of demarcation between it and those darker-tinted varieties favouring the sterile Hawkesbury Sandstone.

The Wianamatta shales cover narrow strips and patches on the main range followed by the Great Western Railway over the Blue Mountains, as far west as near Faulconbridge. Wherever they occur, the handsome turpentine-tree (*Syncarpia laurifoliæ*) is conspicuous. The smooth-barked apple-tree (*Angophora lanceolata*), so characteristic of the prevailing sandstone, stops short at the margin of these shales.

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[1] Proc. Linn. Soc. N.S.W., 1905, XXX, Pt. 3, pp. 376-391.

The Valley had been previously briefly noted by Mr. C. S. Wilkinson,[1] who referred to the presence of trachytic rocks.

In Cox's Journal of Road Construction over the Blue Mountains in 1814, mention is made of feeding and watering stock in the Valley:—"Nine and a half miles (from Emu Plains.—J.E.C.) grass and water in valley to right of road, about a quarter of a mile. Entrance between two rocks."

The absence, or rarity, of dykes within the Blue Mountain region is remarkable, considering their frequency in the coastal areas, as shown on the geological map of the Sydney District recently issued, and described by Mr. M. Morrison.[2]

So far, the Writer has noted a few instances only in the areas under review, viz.:—

Upper Colo, on road about twenty chains south of crossing. Strike, N. 75 degrees E.; thickness about nine feet.
Putty, near School.
" —Snake's Valley, near Putty. Short dyke breaking from volcanic neck.
Kelgoola, Cow Flat, Cudgegong River.
Excelsior, crossing Mudgee Railway Line.
Batten's, near The Pinnacle, Lue district.
Growee Valley, connecting with Gulph Volcanic Neck.

The absence of dykes in the Blue Mountains—where their occurrence would be readily revealed in the vertical valley escarpments—is, to some extent, paralleled by the comparative rarity of volcanic necks in the depressed Sydney Basin, where dykes are so numerous.

It is remarkable how little disturbance the Western Coal Measures have suffered from igneous agency, or regional movements resulting in dislocations or faults.

This singular regularity is in striking contrast to the condition of the Hunter Valley, or Northern Coal-field, as shown on Professor David's maps of the district[3], more particularly in the case of the Lower or Greta Coal

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[1] Ann. Rept. Dept. Mines N. S. Wales for 1882, p. 139.
[2] Records Geol. Survey N.S.Wales, 1904, VII, Pt. 4, pp. 241-281.
[3] Memoirs Geol Survey N. S. Wales—Geology No. 4, 1907, pt. I.

In the Kelgoola volcanic centre the effects of denudation are more pronounced and equable. Enclosing rim-walls, like the neck fillings, have been reduced to common valley levels, outlines have been obliterated, and even soil distinctions obscured by superficial transported material. Here botany, as explained in another section, lends its aid to geology.

Evidence of lineal crustal weaknesses has not been observed; on the contrary, isolated and grouped volcanic occurrences are opposed to fissure origin.

Subterranean energy manifests itself along well-defined terrestrial lines of weakness; but Geikie points out, fissuring is not absolutely essential for the production of volcanoes, that many ancient vents can be demonstrated to have arisen without the help of any visible faults.[1]

On Sheet 13 two other interesting phases of vulcanology are depicted—huge domed laccoliths and massive intrusive sills, the latter having an important bearing on the fertility of the district.

There is considerable uncertainty as to the source of the principal volcanic masses of County Cook, such as Mounts Hay, Banks (or King George), Tomah, Wilson, and Irvine.

Beyond the supposed indication of fissure eruption at Mount Wilson, no direct evidence of extrusion is connected with any of them. Neither pyroclastic detritus, vitrified contact rocks, nor any ocular proof of truncated vents in the intervening valleys, over which the original lava sheet undoubtedly extended, have yet been discovered.

Liquid lavas flow great distances, and maintain comparatively even surfaces. Viscid extrusions, on the contrary, heap up around orifices, forming more or less domed or bulbous masses. The flow represented at the above localities appears to have been of the former character.

The nearest known point of eruption is the recently discovered Powell's Neck—Parish Bilpin, County Cook—two miles south-east of Mount Tootie, a small truncated neck exposed in a tributary channel of Tootie Creek. The highest exposure is about one thousand seven hundred and fifty feet above sea-level, and about eight hundred and seventy feet below the summit of the nearest flow at Mount Tootie. The general level of the plateau sandstone, intersected by the channel, is about six hundred and forty feet lower than the base of the lava sheet mentioned, which rests on a considerable thickness of Wianamatta Shales above the sandstone.

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[1] Text Book Geology, 4th ed., 1903, I, p. 280.

Powell's Neck is a solid plug of olivine-basalt of very limited circumference, with peripheral baking of contact rock, and deposition of laminated iron oxide. Absence of fragmental or tuffaceous materials may point to the complete removal of vent.

Other vents in County Cook, just outside of Sheet 12, are Euroka, The Valley, St. Helena, Mountain Lagoon, and Diamond Hill. Of these, the most extensive are The Valley, St. Helena, and Euroka. These consist of tuffs and agglomerates, with a little basalt in the case of St. Helena, and form fertile hollows or basins considerably below the plateau level. With the exception of the Mountain Lagoon Neck, these occur where the plateau sandstone level is much lower than its extension under the basalt sheet of Tomah, Wilson, &c., owing to stratigraphical inclination of the plateau series; so much lower, in fact, that the vents of these necks (presuming that they were the source of the lava sheet) must have built up fragmental cones to a height of at least two thousand feet above the plateau, to enable lavas to flow at levels represented by the mountain summits mentioned—an assumption involving entire removal of enormously thick connecting masses, or, on the other hand, extrusion of the basalt prior to the western tilting uplift.

Though all the prominent volcanic masses, and numerous others less conspicuous, have been examined in the areas under review, it is certain that other reduced necks will be discovered in the rugged unsurveyed portions, where precipitous cliff escarpments render long detours necessary to gain short direct distances, even on foot.

A number of interesting volcanic necks, particularly in the Macdonald River watershed, outside of the areas shown on the present maps, have been included in these Notes for purposes of record and comparison.

In estimating areas, only the actual volcanic rocks *in situ* have been considered; enriched slopes and taluses, however, considerably increase boundaries of fertility in some cases.

Early References.

Surveyor-General Sir T. L. Mitchell was apparently the first to note the difference of the summit rocks of Mounts Tomah and Hay from the surrounding sandstone. These he recorded as "trap" and "grey porphyry." From the summit of the former, in 1827, he looked into the magnificent gorge, "shut in by stupendous perpendicular cliffs, at the foot of which the silvery line of the Grose, at a depth of three thousand feet below, meanders through a green valley."[1] A view of this transverse stream, doubtless, suggested the possibility of bringing the Great Western road along the valley instead of across the mountain top, for he shortly afterwards attempted its ascent from the Hawkesbury junction, to personally judge of the feasibility of the project. The attempt, however, was abandoned after a few miles only had been accomplished. If the route had been practicable, the narrow divide (at Hartley Vale Platform) between the Grose and Lett, was to have been tunnelled. A bridle-track was subsequently cut by sappers through Grose Valley to the divide mentioned—formerly known as "Darling Causeway."

Mitchell also records an unsuccessful attempt by Surveyor R. Dixon to reach Mount Hay from Grose Valley, on the southern margin of which it stands, but failed to note his success from the Great Western road in February, 1830 (*vide* an unpublished letter to the Surveyor-General, dated 26th February of that year—Survey Records, Department of Lands).

It is remarkable that neither Dixon nor Surveyor W. R. Govett (who ascended it in June, 1831) noticed the difference in the summit rock, though the former remarked the timber.

Govett's announcement of his ascent is interesting, as it contains the first description of the remarkable amphitheatre which bears his name, viz., "Govett's Leap."

"Camp, Blue Mt. Road,
"July, 1831.

"I have the honour to transmit my report for the month of June. This month has been occupied mostly in surveying ranges towards the Grose River and Mount Hay. It may be observed of the mountain feature that it is more remarkable for its deep hollows, than its heights. The general characters of the ranges or creeks, ere they reach the Grose, is similar to those which I surveyed between George's River and the sea—the former being scrubby and the latter commencing in swamps.

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[1] Three Expeditions, 1838, p. 151.

miles, I have succeeded in identifying the sites of about eighty separate volcanic vents, and others have, doubtless, still escaped detection in the interior under the prevalent covering of drift."[1] The same authority states that—"In the inland parish of Carnbee, at least eight distinct orifices of eruption have been detected within an area of about a square mile, and no doubt others still remain buried under the boulder-clay which so thickly covers that part of the district."[2] Again, he records that—"In a single square mile in the eastern part of the parish of St. Andrews, no fewer than seventeen distinct volcanic vents may be counted. A group of at least eight necks is exposed within a horizontal distance of six hundred yards."[3]

Of their mode of occurrence, Geikie states:—"They have been drilled through the solid crust of the earth, sometimes in groups placed close together, less frequently in solitary individuals situated at a distance of several miles from their nearest neighbour."[4]

The vents are more or less circular, owing to equal explosive expansion of the ascending vapours. A possible exception is the Cow Flat neck, in parish Kelgoola, which has an irregular form. E. H. L. Schwarz noted a somewhat similar occurrence, when describing nineteen necks of Matatiele:—"Most of them are rounded pipes, now filled in with agglomerate or dolerite; but one form is dyke-like, and though there is some doubt as to its exact nature, there is very good reason to believe that it was an actual fissure of eruption."[5]

The existence of numerous small vents is regarded by Geikie as evidence of shallowness of the magma, particularly where there is no line of dislocation to aid them. To quote:—"It is obvious that, in order to be able to expel an overlying column of the earth's crust, the magma must have ascended to within a comparatively short distance from the surface. In the case of the innumerable small vents which can be proved to have been drilled through unfaulted rocks, this proximity of the top of the magma to the mouths of the funnels becomes strikingly apparent; and as these vents are numerous, they show that in many cases volcanic action is not deep-seated, but has its source not many hundred feet below ground."[6]

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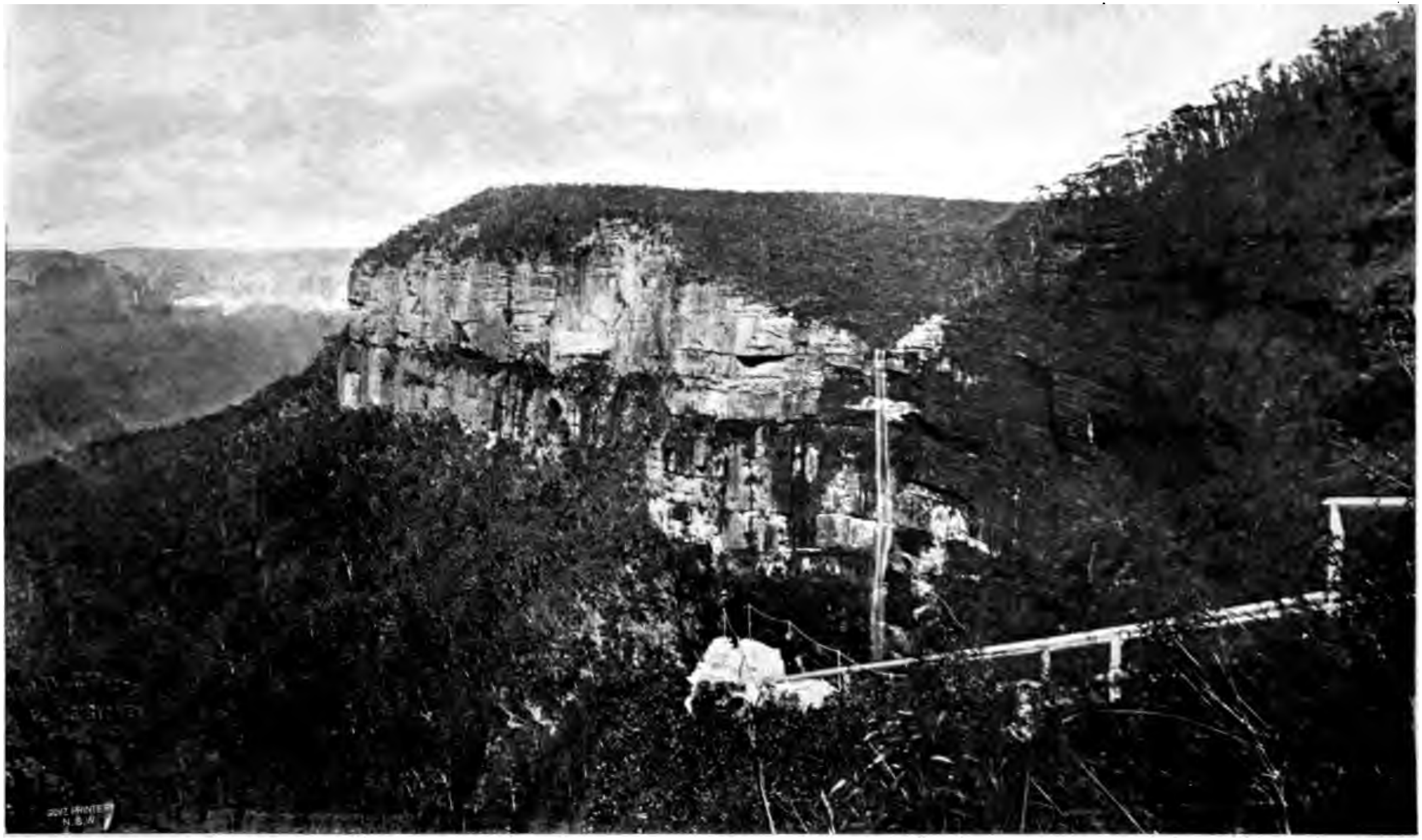
[1] Page 200.
[2] Page 227.
[3] Page 208.
[4] *Ibid.*, p. 204.
[5] The Volcanoes of Matatiele: Ann. Rept. Geol. Comm. Cape of Good Hope, 1902, p. 37.
[6] Text-book of Geology, 4th ed., 1903, I, p. 280.

PLATE VIII.



Kerry & Co.

GOVETT'S LEAP.

In this connection it is interesting to note the result of R. von Drasch's researches. Geikie states that these have shown "that at Bourbon (Réunion), during the early submarine eruptions of that volcano, coarsely crystalline rocks (gabbro) were emitted, that these were succeeded by andesitic and trachytic lavas, but that when the vent rose above the sea, basalts were poured out."[1]

Prismatic or columnar structure is a common feature in flows and necks, and in the contact rocks of dykes and sills. In the Sydney district it is a frequent accompaniment of igneous intrusion in the Hawkesbury Sandstone, the hardened prismatized contact rock being used for road-making under the name of "white metal."

In the areas under review, however, prismatization has not been noticed in the sandstone rim or contact zones, though Surveyor Ogilvie noted instances near Uraterer and Wirraba, in County Hunter.

The first record of this structure in Australia dates from the foundation of settlement. Captain Hunter wrote: "Whilst walking on the shore with the officers of the French ships[2] at Botany Bay, I was shown by them a little mount upon the north shore which they had discovered, and thought a curiosity. It was quite rocky on the top; the stones were all standing perpendicularly on their ends, and were in long but narrow pieces, some of three, four, or five sides, exactly (in miniature) resembling the Giant's Causeway in the north of Ireland."[3]

Shales are sometimes prismatized along intrusive contacts. Coal-seams very commonly assume this structure under similar conditions. In the Stanford Merthyr Colliery, near West Maitland, the coal-seam has been prismatized for over one hundred feet on either side of a dyke. Geikie describes a similar effect of intrusive sheets of basalt in Scottish coal-seams:—"The coal in these cases being beautifully columnar, its slender hexagonal and pentagonal prisms, like rows of stout pencils, diverging from the surface of the intrusive sill.[4] He also mentions that the same structure has been similarly produced in dolomite, limestone, and basalt tuff.

Long continued high temperature in iron furnaces has been observed to have superinduced prismatic structure upon the hearthstones and in the sand in which they are embedded.[5]

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[1] Text-book of Geology, 2nd ed., 1885, p. 236.
[2] La Perouse Expedition, 1788.—J.E.C.
[3] Hunter's Journal, 1793, p. 76.
[4] Text-book of Geology, 4th ed., II, p. 768.
[5] C. Cochrane, Proc. Dudley Geol. Soc., III, p. 54.

That remarkable land-mark—Mount Yengo—on the east bank of the Macdonald River, was surveyed by him in 1831. In 1832 he forced his way on foot from Putty along the divide between the Colo and Hunter, as far west as Coricudgy, on the Main Dividing Range, carrying his blankets and rations for two months. In the same year he struck south-westerly between the Putty or Wollemai and Coorongooba streams to Wirraba, Uraterer, and Mount Molong (now better known as Simmonds Mount). From the latter he doubtless collected the sample described as basalt by Lonsdale.[1]

On his map of these parts Ogilvie marked "whinstone" at Wirraba, also columnar sandstone west of it. Of Wirraba (also named Mount Adams on the Lands Office map), he mentioned that—"The only remarkable objects which I crossed during my survey were the pentagonal columns of basalt on Mount Wirraba; some of them are about twelve feet in length and from two to three feet in diameter. I also met with smaller pentagonal columns of reddish sandstone. I have preserved many specimens of different rocks, among which is a piece of a greyish black basalt, spotted with a soft white substance, interspersed with what I suppose to be transparent felspar."[2]

In 1833 Ogilvie also mapped Wareng, Poppong, Pomany, and Nulla, with intervening ranges.

In 1834 Dr. G. Bennett, F.L.S., described Mount Brace, the remarkable isolated conical peak of plateau sandstone on the Dabee Estate near Rylstone,[3] but overlooked the volcanic necks on its east and west shoulders, and the associated basalt sill which forms lower table hills between Mounts Brace and Cox and Cox's Siding, doubtless owing to the absence of characteristic jungle vegetation, which renders basaltic areas on the more humid eastern face of the mountains so noticeable.

Mitchell, in 1838, described a "mass of dark-coloured trap rock, apparently containing steatitic matter, and doubtless the product of some upheaving force,"[4] at Cox's Basin, at the junction of the Nepean and Warragamba Rivers; since determined as a volcanic neck.

Alan Cunningham, who visited Tomah in November, 1823, referred, in 1842, to a "compact whinstone" at Mount Tomah, whilst describing its flora.[5]

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[1] Three Expeditions, 1838, Appendix.
[2] Unpublished Lands Office Records.
[3] Wanderings in N. S. Wales, 1834, I, p. 122.
[4] Three Expeditions, 1838, I, p. 153.
[5] Hooker's Journ. of Botany, IV, 1842, p. 286.

EFFECT OF IGNEOUS INTRUSION AND EXTRUSION ON COAL-SEAMS.

Where volcanic energy has been grouped in the Coal Measures—as at Kelgoola, Putty, and Barigan—its effect on their productive value becomes a matter of some importance.

Within the area under discussion, four phases of intrusion are manifest in volcanic necks or pipes, laccoliths, sills, and dykes. Of these, probably the first is least harmful, the third most, and the fourth intermediate in possible effect. The rarity of dykes renders their aggregate influence of slight account.

Sills, which are so well developed in the Southern Coal-field, and so vitally influence the fertility of the coastal slopes about Kiama and Jamberoo, in which they outcrop, are represented only in the north-west corner of the Rylstone district (mapped in Sheet 13), but stretch beyond it northwards into the Growee or Bylong Valley, and form rich agricultural soil.

Laccoliths are confined to the same limited area. The effects of the different phases of volcanic energy on the future coal resources of the districts under review must be judged by analogy with similar occurrences, where they can be studied either in natural sections or as a result of mining operations.

Volcanic necks, because of their number, claim first attention. In this case the effect on coal-seams is based upon analogy, for in those centres or foci of extreme energy, denudation has not reached the base of the plateau series which overlie the Coal Measures. Nearer the western margin, in a few instances to be enumerated, denudation has laid contacts bare, but in no case has a coal-seam been seen actually in contact with a pipe, though these are closely approximate. In such cases the effects are circumscribed and comparatively inappreciable.

The mode of occurrence and nature of the force involved in the production of most of the volcanic necks in the area under review, are considered to have practically no metamorphic action on strata pierced by them. Steam and gases, under great compression, gradually perforated the crustal rocks, between the magma and the surface, by explosive drilling, expansion originating in cavities connected or unconnected, with lines of weakness probably determining the loci of the future neck.

seven feet below the surface. It was possibly a large disrupted fragment, floated up by the volcanic rock from the Coal Measures about one thousand four hundred feet below, or, perhaps, derived from a thin seam of coal in the Hawkesbury Sandstone. The coal showed very little sign of having been altered. The volcanic breccia is a tough, black rock, the base of which is very opaque, even in thin slices, and containing abundant small, angular fragments of decomposed dolerite and sandstone, together with numerous sand grains."

"The Valley" breccia mass is described as "oval in shape, about three-quarters of a mile in diameter from east to west, and nearly half a mile from north to south. Towards the centre, a good section is seen of the eruptive rock which is there a very hard volcanic breccia, similar to that already described at Euroka Farm. Crystals of augite are abundantly distributed throughout the mass, and fragments of very slightly-altered bituminous coal, from a fraction of an inch up to three inches in diameter, are very abundant in places. There is evidence of an older and a newer breccia, as fragments of the older breccia may be noticed in places enclosed in the newer. The intrusive character of the mass is proved by the vertical position of large fragments of sandstone, and their alteration near the north-east edge of the intrusion. The surrounding Hawkesbury Sandstones are almost horizontal.

The Valley forms a flat-bottomed depression about five hundred feet below the level of the top of the surrounding Hawkesbury Sandstone, and five hundred and fifty feet above the level of the sea. It is difficult to decide as to the exact part which these eruptive masses at the Valley and at Euroka Farm have played in the basic eruptions which visited this district in Post-Triassic time. The evidence is tolerably clear as to their having intruded the Hawkesbury Sandstone, as well as the Coal-Measures, and as to there having been a powerful upward flow of paroxysmal violence. At first sight, therefore, one would infer that they mark the site of old volcanic chimneys. This was probably their function, though the slightly-altered condition of the fragments of bituminous coal seems incompatible with an intimate association with a matrix of volcanic rock. The highly brecciated character of the mass, however, shows that superheated water, producing violent steam explosions, was probably abundantly present, and this may have protected the coal from calcination, such as it has undergone, when in contact with the basic dykes at Cremorne."

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[1] Ann. Rept. Dept. Mines N. S. Wales for 1882, p. 139.
[2] Records Geol. Survey N.S.Wales, 1904, VII, Pt. 4, pp. 241-281.
[3] Memoirs Geol Survey N. S. Wales—Geology No. 4, 1907, pt. I.

Measures. Here faults are numerous and extensive, the maximum throw or displacement reaching probably five thousand feet, in a fault-plane north of the Hunter River, passing Mount Brooks, the Upper or Newcastle Coal Measures being thrown down against Lower Marine strata.

The western coal workings, moreover, have not to contend with steep dips, as in the the Greta Measures. "Rolls," or undulations, are also insignificant; level courses can be maintained through them with confidence. "Wash-outs," or contemporaneous erosion channels, occur occasionally, but are not serious.

Volcanic Necks.

The Parish of Kelgoola, County Phillip, is remarkable for the number of volcanic necks already noted within its borders. North, south, and east it is bounded by the Main Dividing Range between the eastern and western waters. From the divide, lateral spurs extend, terminating abruptly in volcanic peaks. From Mount Darcy on the east, one terminates in Native-dog Hill; from Duran Duran, another, in Bin Ben Mountain; from Wilworril, a south-western spur ends in Kelgoola, with Midderula about midway.

In the lowlands between these high cones, numerous necks occur, some dominated by high sandstone cliffs, others showing remnants only of their sandstone peripheries. In some instances—as at Mead's Hill—others form the apex of an obtuse cone, consisting of an outlier of sandstone, doubtless owing its survival to contact induration of the rim.

Volcanic energy concentrated at Putty also in several foci. Within a radius of about four miles, in the Parishes of Tupa, Tollagong, Gullongulong, and Putty, County Hunter, at least twenty points of eruption have been mapped.

The necks range from a few chains to about half a mile in diameter.

The number and proximity of the vents, formed chiefly by explosive action, recalls the Eastern Fife district, described by Geikie,[1] where eighty occur within an area of about eighty square miles. To quote the distinguished author:—"In the tract of ground, from six to eight miles broad, which stretches from the coast near St. Andrews south to Lundin Links, a distance of twelve

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[1] Memoirs Geol. Survey Scotland, 1892, p. 200.

Some of the minor channels are regarded by the same authority as apparently "spiracles for escape of superheated vapours, without the ejection of any volcanic detritus, and they are now filled with broken-up sandstone and shale.[1]

Local examples of the latter form have not yet been noted, though large proportions of sedimentary detrital filling have been noticed. In the classic volcanic district of the Eifel, however, it is recorded that amongst the extinct cones "some occur consisting entirely, or nearly so, of comminuted débris of the surrounding Devonian greywacke and slate through which the various volcanic vents have been opened. Evidently in such cases only elastic vapours forced their way to the surface, and we see what probably often takes place in the early stages of a volcano's history, though the fragments of the underlying disrupted rocks are in most instances buried or lost under the far more abundant subsequent volcanic materials."[2]

Necks may be wholly tuffaceous or agglomeratic, or may contain, in addition, a plug of solid lava. In the latter case, the peripheral tuffs, being softer and less coherent are first removed by denudation. Hence, where the rim is obscured by soil and vegetation, it becomes sometimes difficult to determine whether the solid lava marks a vent or remnant of a flow. Fallen trees at times afford a clue by uprooting the tuffaceous subsoil. In numerous instances definite determination must await more extended observation.

Instances, however, are not wanting of considerable induration of fragmental fillings, the Warrumbungles affording notable examples of greater resistances to denudation than the softer rim rocks, the fragmental plugs remaining as conspicuous pinnacles after removal of their peripheries.

Though slight variations have been noted in the composition of solid extrusions from closely approximate vents, average petrological characteristics probably establish common magmatic sources for the different groups, and uniformity throughout. The interesting association of nepheline-ægerine laccoliths with ordinary olivine-basaltic and doleritic necks and sills in the Rylstone-Barigan district has yet to be worked out. The occurrence of nepheline-basaltic necks in the Capertee Valley, and detection of nepheline in others at Umbiella or Nile, Parish Innes, Bin Ben, &c., by Mr. Card, points possibly to a more intimate connection than at present appears to be the case.

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[1] Geol. East. Fife: Mem. Geol. Survey Scotland, 1892, p. 204.
[2] Geikie, Text-book of Geology, 1903, p. 198.

In this connection it is interesting to note the result of R. von Drasch's researches. Geikie states that these have shown "that at Bourbon (Réunion), during the early submarine eruptions of that volcano, coarsely crystalline rocks (gabbro) were emitted, that these were succeeded by andesitic and trachytic lavas, but that when the vent rose above the sea, basalts were poured out."[1]

Prismatic or columnar structure is a common feature in flows and necks, and in the contact rocks of dykes and sills. In the Sydney district it is a frequent accompaniment of igneous intrusion in the Hawkesbury Sandstone, the hardened prismatized contact rock being used for road-making under the name of "white metal."

In the areas under review, however, prismatization has not been noticed in the sandstone rim or contact zones, though Surveyor Ogilvie noted instances near Uraterer and Wirraba, in County Hunter.

The first record of this structure in Australia dates from the foundation of settlement. Captain Hunter wrote: "Whilst walking on the shore with the officers of the French ships[2] at Botany Bay, I was shown by them a little mount upon the north shore which they had discovered, and thought a curiosity. It was quite rocky on the top; the stones were all standing perpendicularly on their ends, and were in long but narrow pieces, some of three, four, or five sides, exactly (in miniature) resembling the Giant's Causeway in the north of Ireland."[3]

Shales are sometimes prismatized along intrusive contacts. Coal-seams very commonly assume this structure under similar conditions. In the Stanford Merthyr Colliery, near West Maitland, the coal-seam has been prismatized for over one hundred feet on either side of a dyke. Geikie describes a similar effect of intrusive sheets of basalt in Scottish coal-seams:—"The coal in these cases being beautifully columnar, its slender hexagonal and pentagonal prisms, like rows of stout pencils, diverging from the surface of the intrusive sill.[4] He also mentions that the same structure has been similarly produced in dolomite, limestone, and basalt tuff.

Long continued high temperature in iron furnaces has been observed to have superinduced prismatic structure upon the hearthstones and in the sand in which they are embedded.[5]

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[1] Text-book of Geology, 2nd ed., 1885, p. 236.
[2] La Perouse Expedition, 1788.—J.E.C.
[3] Hunter's Journal, 1793, p. 76.
[4] Text-book of Geology, 4th ed., II, p. 768.
[5] C. Cochrane, Proc. Dudley Geol. Soc., III, p. 54.

In flows and sills, and in necks wholly or partially filled with solid lava, columnar structure is common. In the Grassy Hill Neck, on the Capertee River, at Mountain Lagoon, and to a lesser extent in the Gulph Neck, on the Bylong-road, it is seen to advantage.

The prisms are usually developed at right angles to the cooling surface from the walls of necks and dykes, and the upper and lower surfaces of flows and sills. Of the latter, magnificent examples of complete prismatization are furnished by the Bumbo flow in the Southern Coal-field, and occasionally fan-shaped disposition of the prisms in connection with dykes.

The well-known association of diamonds, garnets, and other gems in the famous South African volcanic necks naturally directs attention to the possibility of similar occurrences in Australia. Though the writer superficially examined dissected neck fillings, no prospecting has been attempted.

The local tradition as to the discovery of a diamond at Diamond Hill, on the east slope of the Kurrajong ridge, near Richmond, which marks the site of a volcanic neck, must not be lightly regarded, in view of the above possibility.

So far, the only occurrence of a diamond in volcanic matrix in Australia is that recorded by Mr. E. F. Pittman.[1] In this instance, Messrs. Pike and O'Donnell discovered it in altered *dolerite* intruding granite in their mine at Oakey Creek, about eighteen miles south-west of Inverell.

Professor T. W. Edgeworth David exhibited this stone in the matrix before the British Association at York in 1906. The opinion of those best capable of judging being that, like the South African occurrences in volcanic breccia, the diamond in dolerite was adventitious; the dolerite in a viscid condition simply conveying it from great depths.[2]

The supposed occurrence of diamonds in a volcanic pipe at Ruby Hill, near Bingara,[3] has not been authenticated, notwithstanding prospecting under Government aid, and the established strong similarity of its brecciated filling with that of the South African pipes.

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[1] Ann. Rept. Dept. Mines N. S. Wales for 1904, p. 137.

[2] Mr. G. W. Card informs me English experts prefer to class the Oakey Creek rock as *hornblende diabase.*

[3] Mineral Resources of N. S. Wales, 1901, p. 392.

EFFECT OF IGNEOUS INTRUSION AND EXTRUSION ON COAL-SEAMS.

Where volcanic energy has been grouped in the Coal Measures—as at Kelgoola, Putty, and Barigan—its effect on their productive value becomes a matter of some importance.

Within the area under discussion, four phases of intrusion are manifest in volcanic necks or pipes, laccoliths, sills, and dykes. Of these, probably the first is least harmful, the third most, and the fourth intermediate in possible effect. The rarity of dykes renders their aggregate influence of slight account.

Sills, which are so well developed in the Southern Coal-field, and so vitally influence the fertility of the coastal slopes about Kiama and Jamberoo, in which they outcrop, are represented only in the north-west corner of the Rylstone district (mapped in Sheet 13), but stretch beyond it northwards into the Growee or Bylong Valley, and form rich agricultural soil.

Laccoliths are confined to the same limited area. The effects of the different phases of volcanic energy on the future coal resources of the districts under review must be judged by analogy with similar occurrences, where they can be studied either in natural sections or as a result of mining operations.

Volcanic necks, because of their number, claim first attention. In this case the effect on coal-seams is based upon analogy, for in those centres or foci of extreme energy, denudation has not reached the base of the plateau series which overlie the Coal Measures. Nearer the western margin, in a few instances to be enumerated, denudation has laid contacts bare, but in no case has a coal-seam been seen actually in contact with a pipe, though these are closely approximate. In such cases the effects are circumscribed and comparatively inappreciable.

The mode of occurrence and nature of the force involved in the production of most of the volcanic necks in the area under review, are considered to have practically no metamorphic action on strata pierced by them. Steam and gases, under great compression, gradually perforated the crustal rocks, between the magma and the surface, by explosive drilling, expansion originating in cavities connected or unconnected, with lines of weakness probably determining the loci of the future neck.

Ascension would be the natural corollary of succeeding explosive charges until the crust was pierced, when the vent would become funnel-shaped by an inverse process of explosions as the ascending compressed gases and steam found room for sudden expansion at lower levels, as the orifice enlarged, until equilibrium was reached.

Explosive drilling would, superficially, affect the walls of the neck only, hence the absence of stratigraphical disturbance in the neighbourhood, except for inward dip of the surface rim-rocks resulting from subsidence consequent on undermining.

No volcanic necks have been studied under more favourable circumstances, than those of Eastern Fife, described by Sir Archibald Geikie.[1] Occurring as they do on the coast, perfect sections and complete outlines are exposed for investigation.

In their mode of occurrence, filling, and association, the Fife examples closely coincide with some local instances in our western coal areas. Unfortunately, the latter are not open to the same close investigation. Necks within the influence of wave action—like those of Fife—present clean-swept surfaces and practically unaltered contents for both field and microscopic examination. Decomposition, stimulated and accelerated by rank vegetation, rapidly attacks fragmentary fillings of inland necks. Hence, solid unaltered tuffs or agglomerates are rare, heavy soils cover the surfaces, or decomposition extends below the beds of shallow dissecting channels.

Where solid lava wholly or partially fills a neck, as in some local instances, the plutonic heat has superficially affected contiguous strata, sandstones being converted into quartzites, argillaceous rocks into chert or porcellainite. Fragments of such altered rocks are often found within the neck itself.

Care must, however, be exercised in determining the metamorphic influence, for internal evidence as frequently indicates absence of high temperature, even in necks surrounded by similar, altered rim rocks. Heated silicic solutions in the solfataric stage are as capable of metamorphism as dry vitrification. Percolating superficial waters charged with ferruginous or other salts also exert a hardening or cementing effect.

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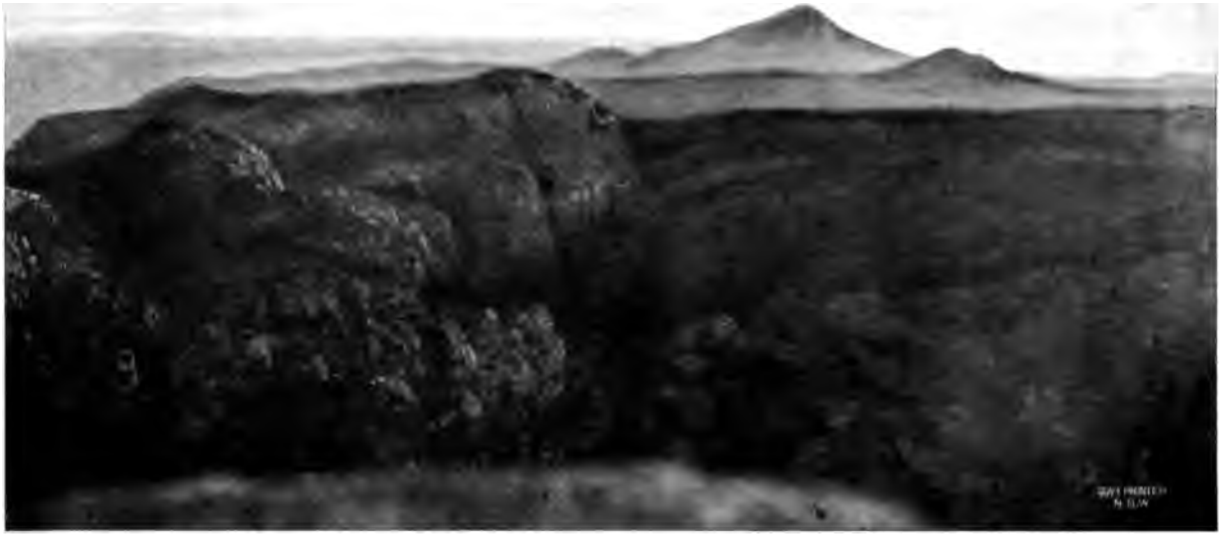
[1] Geology of Eastern Fife, 1892.

PLATE XI.



J. E. Carne.

TAYAN PIC NORTHERN ASPECT FROM MT. DURAMBANG (DUNN'S MT.).

Crater, affords an excellent section of the upper plateau sandstone. Only within about one hundred feet is any disturbance noticeable. At the crater rim the strata have a sudden inward dip, and become quartzitic. Against the latter tuffs and agglomerates rest, having the same inward inclination.

At the Gulph Neck, on the Bylong-road, a coal-seam is exposed in the road-cutting within a short distance of the crater rim, but the coal appears to have only been affected by subsequent weathering.

Near the head of the Cudgegong River, in Parish Kelgoola, a solitary patch of Coal Measures has been uplifted by an intrusive mass partaking of the nature of a dyke, and the shales in actual contact have become converted into flint, but the coal-seam, about fifty feet above the flint band, is unaffected other than by ordinary weathering.

From consideration of the facts adduced, it appears reasonable to assume that the influence of volcanic necks on productive Coal Measures is little more than proportional to the areas of the intruded mass at any given level. Though collectively great, the total area of destruction represented in the necks is relatively insignificant in the wide expanse of Coal Measures.

Three laccoliths occur within the area depicted on Sheet 13,—Bald Mountain, The Pinnacle, and one unnamed in the extreme north-west. Altogether, twelve of these interesting phenomena occur in an area of about thirty-four square miles. They consist of *tinguaite* of highly ornamental texture and colour. One of the nearest to railway carriage—The Pinnacle—has, since its discovery during the geological survey, been secured under a quarry lease, the stone being intended for ornamental purposes, as it takes a good polish.

Each of these laccoliths intrudes the Coal Measures and wholly or partially uplifts the Triassic Series, revetments of which are still to be seen on the shoulders of some.

Around the periphery of Bald Mountain, Coal Measures are upturned. In close proximity on the south-east border is a coal-seam apparently showing no evidence of the contact of such an enormous intrusive mass.

Neck Filling, agglomerates, tuffs, and olivine-basalt. Remains of flow of latter on sandstone ridge a short distance south. Neck-basin richly grassed, open forest.

[5815] **Nepheline-Basalt.**—Colour, greyish-black; fracture, hackly or uneven; texture, aphanitic, but almost doleritic.

Under the microscope it is distinctly holocrystalline, and microporphyritic with small phenocrysts of serpentinized olivine, which are sometimes completely automorphic. Small crystals of pale augite, much elongated in the direction of the prism axis, are plentiful. Nepheline is abundant, and forms distinct crystals. It may show some discoloration, but is otherwise fresh. Magnetite crystals are disseminated throughout. Felspar has not been recognised.

[5815a] This variety differs from the foregoing only in being finer in grain. It is very compact, and breaks with a sub even fracture. Olivine is occasionally visible.

Broken Forest Neck, Sheet 14, Portion 24, Parish Coolcalwin, County Phillip. Elevation, about two thousand three hundred and eighty-five feet above sea-level. Composition, olivine-basalt. Area, about ten acres.

Brown's Mount, Sheet 12, Parish Rock Hill, County Cook, consists of two small closely adjacent cones of olivine-basalt, from forty to fifty feet in thickness.

Heights above sea-level, approximately three thousand six hundred and forty-five and three thousand six hundred and seventy-five feet.

[6214] **Olivine-Basalt.**—A greyish-black rock, breaking with an uneven fracture. Olivine is scattered through it in considerable quantity. The texture tends to become doleritic.

Under the microscope the phenocrysts of olivine are abundant. They are quite fresh, but have been much corroded. The groundmass is granular and distinctly holocrystalline. It consists of augite, olivine, labradorite, and magnetite (crystallized).

Mount Caley, Sheet 12, Parish Irvine, County Cook, covered by thin cap of flow basalt. Named by the writer in honor of George Caley, Botanist, who first penetrated as far as Mount Banks (or King George) the latter end of 1804.

[6270] **Olivine-Basalt.**—Black in colour, fracture rather hackly. Olivine is freely visible.

Under the microscope the groundmass is fluxional, with abundant oriented microlites of fresh plagioclase. Olivine forms corroded phenocrysts, which show some serpentinization. Magnetite is sparsely scattered through the groundmass in the form of tiny crystals.

Clear Farm Neck, Portions 13 and 14, Parish Gullongulong, County Hunter. Elevation, about eight hundred and sixty-five feet above sea-level. Area, about one hundred and eighty-five acres. Clear Farm forms a circular basin in dominating Hawkesbury Sandstone. The neck filling consists of coarse tuffs, with water-worn pebbles of quartz and slate, and fossil wood from the underlying Upper Marine Beds and Upper Coal Measures, pierced by explosive vapours during eruption.

Of the disastrous effects of sills numerous instances are recorded, the best known local instance being that of Bulli, where the principal coal-seam in the Southern Coal-field has suffered destruction over considerable areas, and in others has been converted into natural coke, with prismatic structure.

Geikie refers to the effect of intrusive sheets of basalt on certain Scotch coal-seams, the coal being beautifully columnar, its slender hexagonal and pentagonal prisms resembling stout pencils diverging from the surface of the sill.[1]

Sills sometimes convert intruded bituminous coal-seams into anthracite by driving off its volatile hydrocarbons and hygroscopic moisture. A local instance is recorded by Professor David at Mittagong, where an intrusive sheet of syenite has converted contact coal into anthracite.[2]

Professor Arthur Lakes,[3] describing anthracitization in the Zampa Coal-field, Colorado, at Pilot Knob, says that "The anthracizing lava sheet may in some cases be above, and in others below, the coal-seam. In both positions, if the lava sheet is sufficiently near to the coal-seam, its tendency is to anthracize it. Some observers have claimed that the strongest anthracizing effects are when the lava sheet is below the coal, as heat and hot vapours ascend. Too close proximity of an intrusive sheet is apt to destroy coal or turn it into a useless coke or an impure graphite."

Local instances of graphitic carbonization resulting from granitic intrusion occur at Undercliff, near Wilson's Downfall, in New England, and at Mount Bopple, in Queensland.

An estimate of the probable effect of sills on productive Coal Measures would be purely empirical, unless supported by close local observation or practical test. So far, however, as mapping has progressed, apparently little or no damage has been wrought by them in the area under review.

The effect of dykes on coal-seams is a varying quantity, ranging from practically nil to serious proportions. Why a molten intrusive mass should in some instances exert so slight, and in others so great, an effect on a combustible substance like coal is a problem not easily solved.

In the Northern and Southern coal-fields dykes are of common occurrence. So far, the Western coal workings are free of them.

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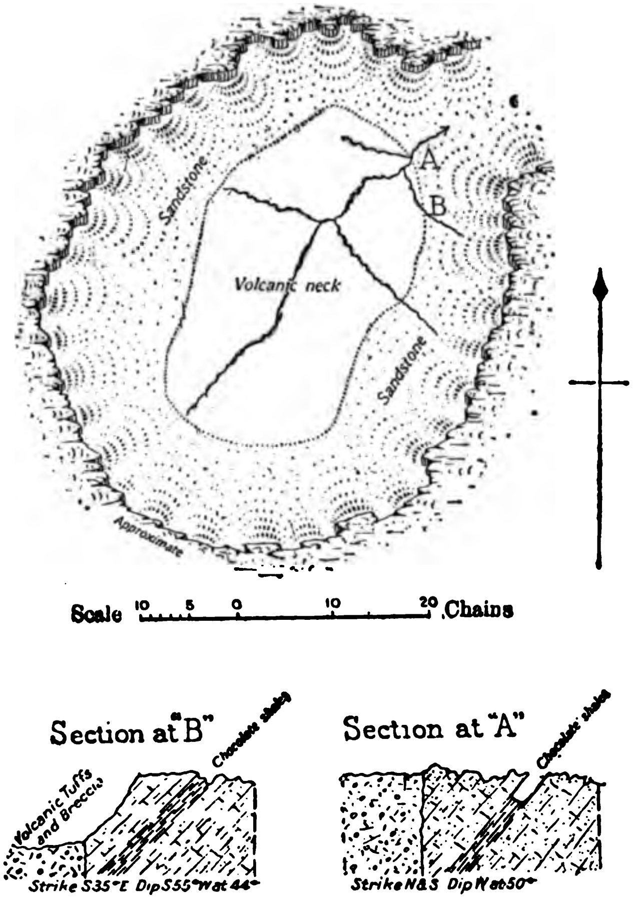
[1] Text-book of Geology, 4th ed., 1903, II, p. 769.
[2] Ann. Rept. Dept. of Mines, N. S. Wales, 1888, p. 90.
[3] Mines and Minerals, XXIV, No. 6, pp. 249-251.

seventy acres of richly-soiled, open forest land. Filling apparently wholly tuffaceous. Contact sections show inversion of rim, and expose Chocolate Shales.

[5550] **Volcanic Agglomerate,** bluish in colour.—This consists chiefly of quartz and sandstone. Some volcanic lapilli, and carbonaceous matter showing vegetable tissue, are present.

Cox's Creek Sill, Sheet 13, Parish Dabee, County Phillip. Thickness, about one hundred feet.. Intrusive in Coal Measures, near top of series. Similar to Tongbong Mountain Sill. Composition [6653] olivine-basalt. Glassy in colour, breaking with a splintery fracture. Small grains of fresh olivine are readily visible.

FIG. 5.—CONDON CLEAR VOLCANIC NECK.



Cow Flat Neck, Sheet 14, east of Portion 4, Parish Never Never, County Phillip. An irregular-shaped intrusive mass on the Cudgegong River, which has lifted a small portion of the Coal Measures to view, and exposed a coal-seam. It is interesting to note that whilst the contact shales

Head of the Hole, Putty [**5822**]—distinct and more or less automorphic crystals of nepheline may be seen[1]; at other times it is interstitial in the groundmass. It seems probable that nepheline is almost always present, although not, perhaps, recognisable. In the Sydney area, nepheline occurs as automorphic crystals in the basalt from the small neck at North Dural. Analcite is often recognisable in the groundmass, and is frequently traversed by the colourless acicular inclusions noticed at Bondi and elsewhere.[2] Nepheline may become entirely dominant over felspar, and the latter may even be practically absent, as it is in the three instances just cited.

Olivine is universally present. In many instances it is megascopic in character, and sometimes occurs as conspicuous masses,—as, for instance, at Mount Coorongooba [**5858**].

The contents of heavy metals are unusually low. This is notably the case with manganese, which is in considerably smaller amount than is commonly the case. Copper has not been detected in any of the rocks analysed. This absence of copper is noteworthy, since native copper occurs in the Bumbo and other basalts, and (together with carbonate) in the tuffaceous beds of the Narrabeen Stage. Chromium, cobalt, and nickel occur in several; barium in all.

Considerable textural variation is shown by these rocks. Basalt-glass occurs at Coricudgy [**5879**], Coorongooba [**5861**], and in the Moen Tuff [**5556A**]. Ordinary basaltic texture is common; but the crystalline condition of the groundmass sometimes becomes distinctly doleritic without the rock always losing its porphyritic character. The Midderula rock is the most coarsely crystalline of the series.[3]

Coricudgy may be cited as another distinctly doleritic type [**5878**]. An ophitic dolerite occurs at the Mountain Lagoon (**5538**). In the rock from Green Hill, County Cook [**6215**], very distinct felspar phenocrysts are present.

A very small number remains which cannot be strictly placed within the basalt group. These are—

Trachytic basalt, Mount Molong or Mount Simmonds [**5542**].
Augite-porphyry, Midderula [**5873**].
Quartz-porphyry fragments found in some of the necks.

On a previous occasion,[4] reference has been made to the frequent presence of basic xenoliths in these intrusives.[5] Such inclusions were noticed in the following:—Pinnacles [**5884**], Snake Valley [**5805**], Murray Mount [**6216**], and Green Hill, County Cook [**6215**].

Attempts at geographical grouping were not successful. The only conceivable division is based upon the proportion of nepheline molecules present, and for that, chemical analysis would be required of every rock. From the analyses that have been made, it seems probable that the magma was homogeneous; mineralogical differences are slight in character, and may be regarded as fortuitous.

A few rocks of these districts have recently been described elsewhere, and are, therefore, not referred to here. Among these are the olivine-basalt from Tayan Peak,[6] and the nepheline basalt capping The Peak, Upper Burragorang.[7]

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[1] Card, Mingaye, and White. Analcite-Basalt from the Sydney District. Records Geol. Survey N. S. Wales, 1902, VII, pp. 93–109.

[2] *Loc. cit.*

[3] It will be noted (p. 123) that its specific gravity is correspondingly high.

[4] Card.—An Eclogite-bearing Breccia from the Bingara Diamond Field.—Records Geol. Survey N. S. Wales, 1902, VII, p. 39.

[5] Quartz grains are not uncommon, as may be expected, since beds of gritty sandstone have been traversed.

[6] Kerosene Shale Deposits of N. S. Wales. Geological Survey Memoir, No. 3, p. 317.

[7] On the Occurrence of Nepheline in Post-Triassic Basalts of the Hawkesbury Series. Records Geol. Survey N. S. Wales, 1903, VII, p. 236.

north-west foot of mountain, five hundred and sixty-three feet below the summit. The neck has been intersected to a depth of seventy feet by small channel, exposing agglomerate and tuffs. Only instance yet noted in connection with tinguaites.

Davis' Hole Neck and Gosper's Hole Neck, Sheet 14, Parishes Coorongooba and McLean, County Hunter. These secluded circular hollows recall Boldrewood's description of the Bushranger's Retreat in "Robbery Under Arms," so secure, and so unsuspected are they amid rugged surroundings. The explorer little anticipates such veritable oases cradled deep in desolate stony barrenness. Unfortunately, remoteness and inaccessibility render them of little economic importance.

The two necks are separated by a narrow ridge of plateau sandstone, forming the main divide between Coorongooba and Wirraba waters. Each is surrounded by a perfect wall of sandstone, mostly precipitous. From each issues a channel cutting the lower rim, and escaping through vertical cliffs. The surrounding plateau rises about one thousand feet above the bottom of the deepest neck, and about three thousand above sea-level. The intervening ridge between the necks rises about five hundred and sixty feet above their lowest exposures. Chocolate Shales are exposed on west side of this divide, about one hundred feet below its summit. The area of Davis' Hole is about one hundred and fifteen acres; that of Gosper's Hole, about seventeen acres.

The neck fillings consist mostly of tuffs and agglomerates; in Davis', a small knoll of olivine-basalt occurs.

Gosper's Hole, County Hunter.

[5849] **Olivine-Basalt.**—A greyish-black, jointed rock, platy in structure, and breaking with a hackly cross-fracture. It is thickly studded with small masses of olivine.

Under the microscope, augite and plagioclase are seen as phenocrysts in addition to olivine. The olivine is fresh, and often automorphic, but is much corroded. In one instance it was noticed to include augite. The phenocrystalline augite is irregular for the most part, and is much less plentiful than olivine. It is often twinned. The colour varies from pale brown to violet, but pleochroism was not noticed. Augite also occurs as areas of aggregated crystals and grains, with which a little felspar and olivine is entangled. In one of these areas magnetite has separated out in the form of branching rods. It seems certain that the rock in its present form is the result of the fusion of pre-existing basic igneous rocks.

[5850] **Volcanic Agglomerate**, dark in colour, and much decomposed.

[5851] **Felspar-Porphyry.**—A considerably altered rock, with pink felspars in a chocolate groundmass.

Bald Hill Neck, Right Nile, Sheet 14, Parish Coorongooba, County Hunter. Elevation about two thousand eight hundred and seventy feet above sea-level. Thickness of basalt above sandstone about eighty feet. Tuffs present. Area about twenty acres. Well grassed. Used as sheep-run. Situated between and near heads of Right Nile and Coorongooba Creeks.

[5852] **Olivine-Basalt**.—A bluish-black rock, with platy fracture. Olivine and augite are plentiful, the former sometimes occurring in conspicuous masses.

Under the microscope, phenocrysts of olivine and augite lie in a fine-grained groundmass. Olivine forms irregular masses, the smaller of which are pseudomorphously replaced by serpentine, while the larger are fresh. Augite is colourless, save for a violet tinge marginally; it also occurs as irregular masses. Some exogenic grains of quartz, enveloped by an altered mantle, are present. The groundmass is even and fine-grained, consisting of granular augite, tiny plagioclase microlites, and pigmental magnetite.

Bald Hill Forest Neck, near Bald Mount, Sheet 14, Parish Kelgoola, County Phillip. Elevation, about two thousand six hundred and ninety-three feet above sea-level. Area, half an acre. Circular shape, characteristic neck forestry. Composition obscured.

Basalt Nob Neck, Sheet 14, Parish Innes, County Hunter, about two miles north-east of Mount Uraterer, occurs under similar conditions to Gosper's Nob. Height, about two thousand four hundred and forty feet above sea-level. Summit, about forty feet above surrounding sandstone rim, which is highly ferruginous.

Area, about half an acre.

[5543] **Olivine-Basalt** (nepheline-bearing).—A greyish-black, jointed rock, breaking with a sub-even fracture. Some olivine is visible. One specimen is dotted with tiny, partially-filled vesicles.

Under the microscope abundant phenocrysts (more or less automorphic) of fresh olivine are embedded in a distinctly holocrystalline groundmass. The groundmass is granular: it consists of augite, plagioclase, magnetite, and a base of feebly double refracting material, regarded as nepheline. Highly altered xenoliths occur occasionally.

Bin Ben Neck (?), Sheet 14, Parish Kelgoola, County Phillip. Forms a conical hill; elevation of top, about three thousand eight hundred feet above sea-level. In Hawkesbury Sandstone. Exact nature of occurrence not ascertained. Area, about one hundred and seventy-five acres.

[5859] **Olivine-Basalt** (nepheline-bearing).—Colour, greenish-black; fracture, hackly. Olivine is abundant, and sometimes occurs as conspicuous masses. The groundmass can almost be resolved with a lens.

Under the microscope the groundmass is distinctly holocrystalline, consisting of granular augite, nepheline, felspar, and magnetite. Olivine is fresh, and forms both automorphic and irregular phenocrysts.

"North of Portion 24, in same parish, a mass of basalt—apparently a neck—is exposed, from the top of the Hawkesbury Sandstone range almost to the Bogie Basin level. Actual junctions are obscured, but the intruded Coal Measures are seen to be indurated in places.

"In portion 15, Parish Tayar, County Roxburgh, three small outcrops of basalt occur on the edge of Bogie Nile Flat, forming in each case a small knob above the surrounding Coal Measure shales, which are indurated in places. Probably remnants of small necks."

Boorowal Swamp Neck, east of Sheet 14, and outside of mapped area, Parish Wareng, County Hunter. Elevation, about one thousand feet above sea-level. Forms low hill, with lower sandstone rim; filling, basalt and tuffs. Area, about 3·4 acres.

[5816] **Volcanic Breccia.**

[5816a] **Olivine-Basalt.**—Colour, black; fracture, uneven. Phenocrysts of olivine, varying in size up to 5 millimetres, are abundant. The dropping out of these gives rise to pitting on weathered surfaces.

Under the microscope, the olivine phenocrysts are seen to be much corroded by the magma; a crystal may be hollowed out, or split up into fragments. The groundmass is very dense. Tiny microlites of felspar are recognisable, and specks of magnetite are abundant, and there is certainly a base present, but the groundmass cannot be satisfactorily resolved.

Box Bump Neck (?), Sheet 14, portion 39, Parish Tollagong, County Hunter. Elevation, about one thousand six hundred and forty feet above sea-level. Forming a small round knob, rising about twenty feet above level of sandstone range; surrounded by a rim of iron oxide. Probably a neck; evidence not conclusive. Area, about ·3 acre. Derives its name from occurence of the coastal variety of white box (*E. hemiphloia*).

[5549] **Olivine-Basalt.**—A black, very compact rock, breaking with a lumpy fracture. Yellow-green masses of olivine are conspicuous.

Under the microscope, olivine is perfectly fresh and quite irregular in form. The groundmass is dense, and thickly studded with magnetite specks; it is very slightly amygdaloidal. An occasional phenocryst of purplish augite occurs, and one mass of pleonaste was observed. Felspar exists only as tiny microlites in the groundmass.

Boxy Clear Neck, Sheet 14, Portion 28, Parish Tollagong, County Hunter. Elevation, about one thousand feet above sea-level. Surrounding Hawkesbury Sandstone plateau rises about one thousand five hundred and sixty feet above sea-level. Contact junction with Chocolate Shales exposed at one point, with almost vertical inward dip.

Neck Filling, agglomerates, tuffs, and olivine-basalt. Remains of flow of latter on sandstone ridge a short distance south. Neck-basin richly grassed, open forest.

[5815] **Nepheline-Basalt.**—Colour, greyish-black; fracture, hackly or uneven; texture, aphanitic, but almost doleritic.

Under the microscope it is distinctly holocrystalline, and microporphyritic with small phenocrysts of serpentinized olivine, which are sometimes completely automorphic. Small crystals of pale augite, much elongated in the direction of the prism axis, are plentiful. Nepheline is abundant, and forms distinct crystals. It may show some discoloration, but is otherwise fresh. Magnetite crystals are disseminated throughout. Felspar has not been recognised.

[5815a] This variety differs from the foregoing only in being finer in grain. It is very compact, and breaks with a sub even fracture. Olivine is occasionally visible.

Broken Forest Neck, Sheet 14, Portion 24, Parish Coolcalwin, County Phillip. Elevation, about two thousand three hundred and eighty-five feet above sea-level. Composition, olivine-basalt. Area, about ten acres.

Brown's Mount, Sheet 12, Parish Rock Hill, County Cook, consists of two small closely adjacent cones of olivine-basalt, from forty to fifty feet in thickness.

Heights above sea-level, approximately three thousand six hundred and forty-five and three thousand six hundred and seventy-five feet.

[6214] **Olivine-Basalt.**—A greyish-black rock, breaking with an uneven fracture. Olivine is scattered through it in considerable quantity. The texture tends to become doleritic.

Under the microscope the phenocrysts of olivine are abundant. They are quite fresh, but have been much corroded. The groundmass is granular and distinctly holocrystalline. It consists of augite, olivine, labradorite, and magnetite (crystallized).

Mount Caley, Sheet 12, Parish Irvine, County Cook, covered by thin cap of flow basalt. Named by the writer in honor of George Caley, Botanist, who first penetrated as far as Mount Banks (or King George) the latter end of 1804.

[6270] **Olivine-Basalt.**—Black in colour, fracture rather hackly. Olivine is freely visible.

Under the microscope the groundmass is fluxional, with abundant oriented microlites of fresh plagioclase. Olivine forms corroded phenocrysts, which show some serpentinization. Magnetite is sparsely scattered through the groundmass in the form of tiny crystals.

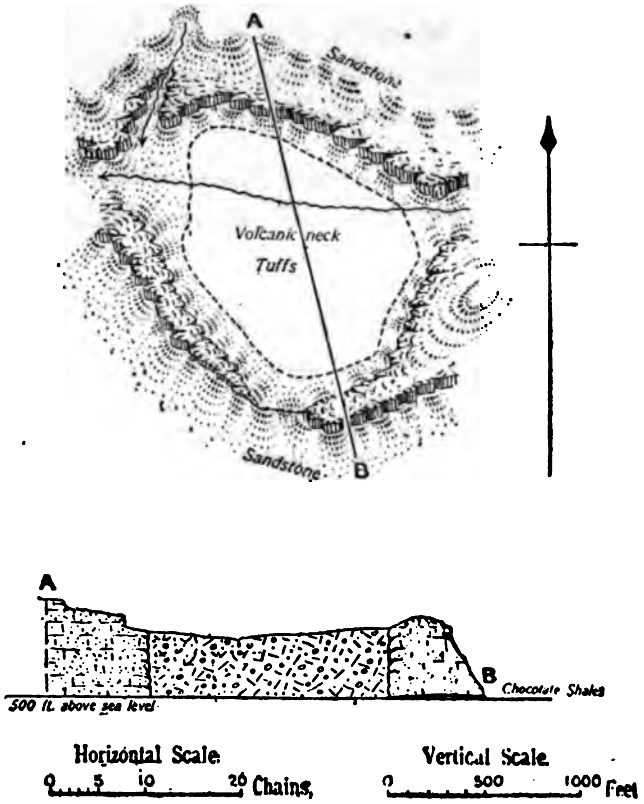
Clear Farm Neck, Portions 13 and 14, Parish Gullongulong, County Hunter. Elevation, about eight hundred and sixty-five feet above sea-level. Area, about one hundred and eighty-five acres. Clear Farm forms a circular basin in dominating Hawkesbury Sandstone. The neck filling consists of coarse tuffs, with water-worn pebbles of quartz and slate, and fossil wood from the underlying Upper Marine Beds and Upper Coal Measures, pierced by explosive vapours during eruption.

The Chocolate Shales occur about one hundred and twenty feet below the surface of the abbreviated neck, but are not seen in contact. The sandstone rim-rock has an inward dip. The Putty-Singleton road passes over the neck. Between the latter and Boggy Swamp, Chocolate Shales are typically developed along the road.

[5827] **Tuff.**—A yellowish, sandstone-like, even-grained, gritty rock, weathering brick-red. Much quartz, and lapilli of fine-grained lava are discernible under the microscope.

[5551] **Volcanic Agglomerate.**—Highly ferruginous, and containing much quartz.

FIG. 4.—CLEAR FARM NECK.



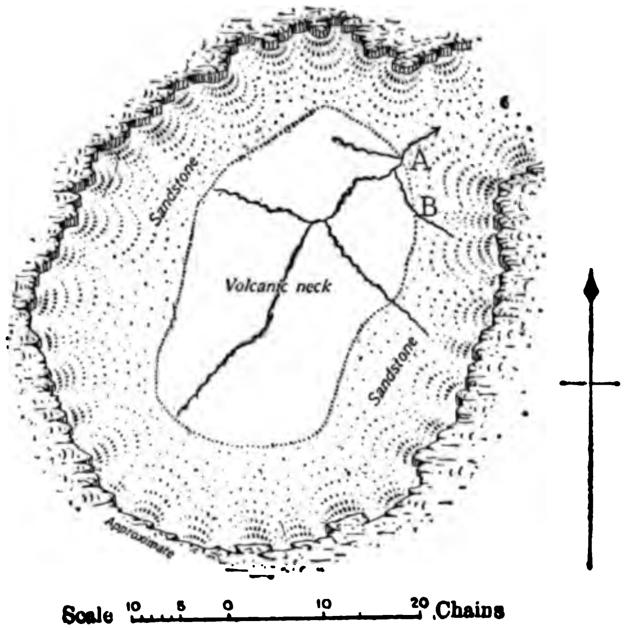
Box Gap Neck, Sheet 14, Parish Tupra, County Hunter. Elevation, about one thousand one hundred and sixty-five feet above sea-level. Situated on side of saddle in range between Warwallah Creek and tributary of Swampy Arm. Sandstone rim-rock hardened. Filling, tuffaceous. Area, about seven acres.

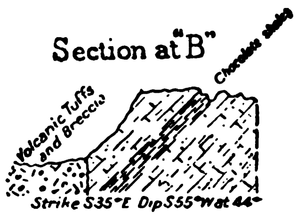
Condon Clear Neck, Sheet 14, Parish Tollagong, County Hunter. Elevation, about one thousand one hundred and ninety feet above sea-level. A basin-shaped hollow surrounded by sandstone ridges, containing about seventy acres of richly-soiled, open forest land. Filling apparently wholly tuffaceous. Contact sections show inversion of rim, and expose Chocolate Shales.

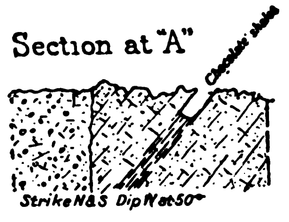
[5550] Volcanic Agglomerate, bluish in colour.—This consists chiefly of quartz and sandstone. Some volcanic lapilli, and carbonaceous matter showing vegetable tissue, are present.

Cox's Creek Sill, Sheet 13, Parish Dabee, County Phillip. Thickness, about one hundred feet.. Intrusive in Coal Measures, near top of series. Similar to Tongbong Mountain Sill. Composition [6653] olivine-basalt. Glassy in colour, breaking with a splintery fracture. Small grains of fresh olivine are readily visible.

FIG. 5.—CONDON CLEAR VOLCANIC NECK.







Cow Flat Neck, Sheet 14, east of Portion 4, Parish Never Never, County Phillip. An irregular-shaped intrusive mass on the Cudgegong River, which has lifted a small portion of the Coal Measures to view, and exposed a coal-seam. It is interesting to note that whilst the contact shales have been converted into cherts of a flinty character, the closely adjacent coal-seam has not been affected. Elevation above sea-level, about two thousand three hundred to two thousand four hundred feet. Dominated by cliffs of sandstone in places.

About one hundred and fifty feet above the neck-level, two small patches of basalt occur on the sandstone, evidently remnants of a flow.

Area, about two hundred and fifty acres.

[5363] **Olivine-Dolerite.**—A greyish-black, jointed rock, with uneven fracture. The constituent minerals are readily discerned with the unaided eye.

Under the microscope it is seen to consist of augite, labradorite, olivine, and magnetite. Olivine is comparatively abundant; its crystals are seldom automorphic. All the constituents are quite fresh. The plagioclase is at least as basic as labradorite.

Cumbermelon Mountain, Parish Clandulla, County Roxburgh, near [4621] Olivine-Basalt flow.[1]

Currant Mountain Neck, Sheet 14, Parish Ganguddy, County Roxburgh. Height, about three thousand two hundred and sixty-three feet above sea-level. Exposed on west side to a depth of three hundred feet. Tuffs and iron ore occur at the rim contact of plateau sandstone, which is highly vitrified, and inclined inwards. The rim rises fifty feet higher on northern shoulder. Area, about forty acres.

[5843] **Nepheline-Basalt.**—A black rock, breaking with a lumpy fracture. Olivine is visible.

Under the microscope, phenocrysts of olivine and some of augite are embedded in a groundmass of augite, magnetite, and nepheline. The olivine phenocrysts show some traces of automorphism, and are occasionally much corroded; the mineral is but slightly altered. Those of augite are automorphic, and light violet in colour; they contain glass-inclusions abundantly. The groundmass consists chiefly of granular augite, magnetite (as disseminated little crystals), and poikilitic nepheline. The areas of nepheline are clear, and envelop the other constituents of the groundmass; the mineral, thus, does not constitute a general base. Occasionally cubic cleavages can be seen. Felspar is apparently absent.

Dairy Mount, Sheet 13, Parish Rumker, County Phillip. Height above sea-level, about three thousand one hundred and eighty-eight feet; rises about one thousand and eighty-eight feet above Dairy Creek, at its south-east foot. Plateau sandstone cliffs rise to two thousand nine hundred and seventy-eight feet. Cap of mountain formed of flow-rock analagous to Barigan tinguaites; evidently derived from volcanic neck of similar rock at north-west foot of mountain, five hundred and sixty-three feet below the summit. The neck has been intersected to a depth of seventy feet by small channel, exposing agglomerate and tuffs. Only instance yet noted in connection with tinguaites.

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[1] Memoirs Geol. Survey N. S. Wales, Geol. No. 3, 1903, p. 155.

Davis' Hole Neck and Gosper's Hole Neck, Sheet 14, Parishes Coorongooba and McLean, County Hunter. These secluded circular hollows recall Boldrewood's description of the Bushranger's Retreat in "Robbery Under Arms," so secure, and so unsuspected are they amid rugged surroundings. The explorer little anticipates such veritable oases cradled deep in desolate stony barrenness. Unfortunately, remoteness and inaccessibility render them of little economic importance.

The two necks are separated by a narrow ridge of plateau sandstone, forming the main divide between Coorongooba and Wirraba waters. Each is surrounded by a perfect wall of sandstone, mostly precipitous. From each issues a channel cutting the lower rim, and escaping through vertical cliffs. The surrounding plateau rises about one thousand feet above the bottom of the deepest neck, and about three thousand above sea-level. The intervening ridge between the necks rises about five hundred and sixty feet above their lowest exposures. Chocolate Shales are exposed on west side of this divide, about one hundred feet below its summit. The area of Davis' Hole is about one hundred and fifteen acres; that of Gosper's Hole, about seventeen acres.

The neck fillings consist mostly of tuffs and agglomerates; in Davis', a small knoll of olivine-basalt occurs.

Gosper's Hole, County Hunter.

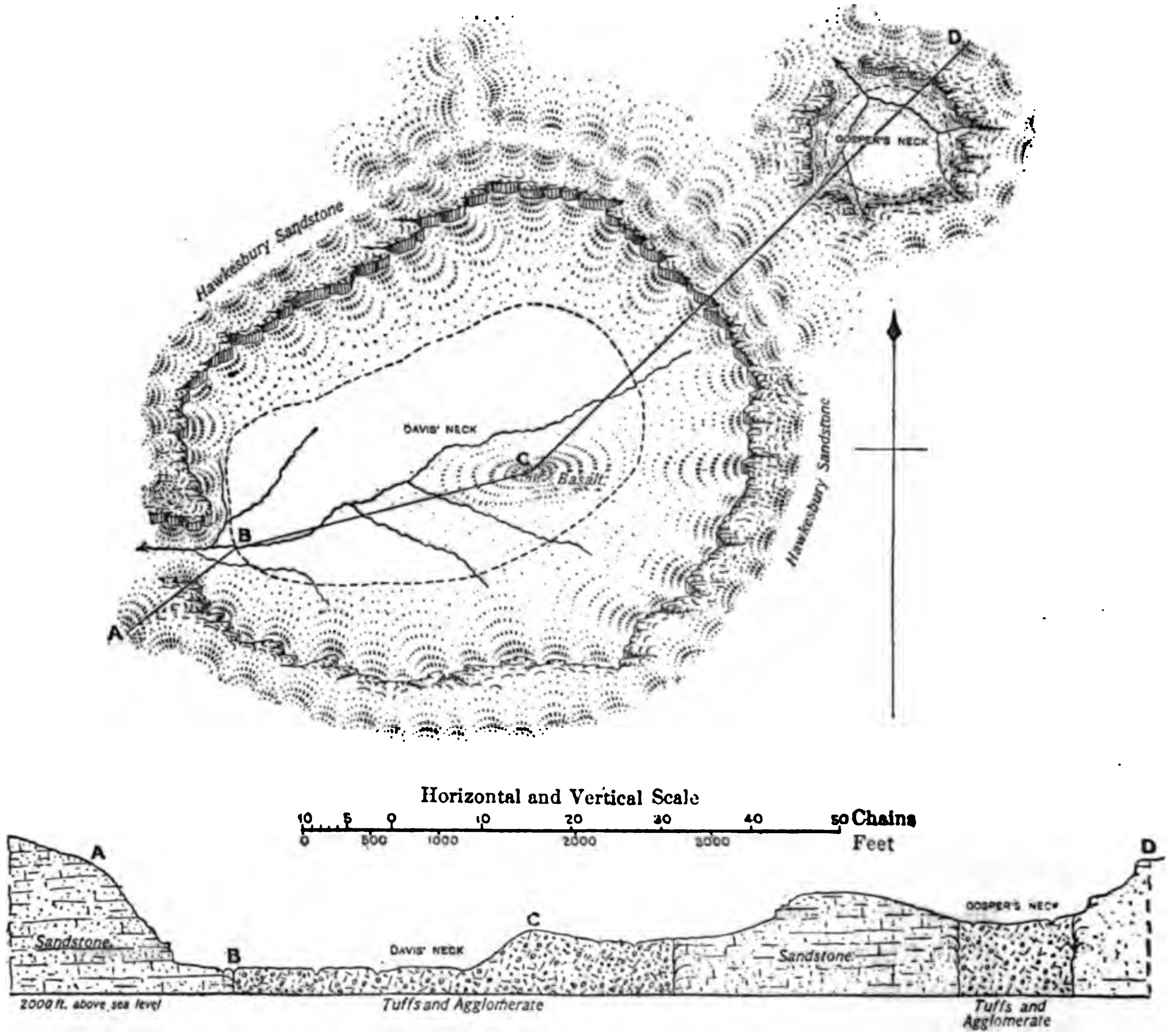
[5849] **Olivine-Basalt.**— A greyish-black, jointed rock, platy in structure, and breaking with a hackly cross-fracture. It is thickly studded with small masses of olivine.

Under the microscope, augite and plagioclase are seen as phenocrysts in addition to olivine. The olivine is fresh, and often automorphic, but is much corroded. In one instance it was noticed to include augite. The phenocrystalline augite is irregular for the most part, and is much less plentiful than olivine. It is often twinned. The colour varies from pale brown to violet, but pleochroism was not noticed. Augite also occurs as areas of aggregated crystals and grains, with which a little felspar and olivine is entangled. In one of these areas magnetite has separated out in the form of branching rods. It seems certain that the rock in its present form is the result of the fusion of pre-existing basic igneous rocks.

[5850] **Volcanic Agglomerate,** dark in colour, and much decomposed.

[5851] **Felspar-Porphyry.**—A considerably altered rock, with pink felspars in a chocolate groundmass.

FIG. 6.—DAVIS' AND GOSPER'S HOLES VOLCANIC NECKS.



Diamond Hill Neck, outside and east of Sheet 12, Portion 109, **Parish** Kurrajong, County Cook. At the apex of an angle formed **by junction of** Little Wheeny and Blue Gum Creeks. Form roughly circular. **Area, about** ten acres. Height above sea-level, about six hundred and forty **feet. Two-**thirds of tuffaceous rim broken down and obscured by denudation, **remainder** forming wall twelve to fifteen feet in height. Filling partly **olivine-basalt,** partly tuff. Rim-rock Hawkesbury Sandstone, with Wianamatta Shales capping hill summit. The suggestive name it bears is locally derived from traditional discovery of a diamond at the spot.

[5739] **Olivine-Basalt.**—Porphyritic, with conspicuous crystals of fresh, clearly striated felspar; colour, greyish-black; fracture, hackly.

Under the microscope, large phenocrysts of fresh labradorite, and smaller ones of olivine, are set in a fluidal groundmass of felspar laths, augite, and magnetite. The felspar phenocrysts are externally corroded, and contain numerous stone inclusions, which usually follow the twin planes.

[5739A] is more fine-grained, and contains some glass. The felspar phenocrysts have been deeply invaded by tongues of groundmass, without being otherwise much corroded. Portions of this invading groundmass are clear and spherulitic.

Dingo Forest Neck, Sheet 14, Parish Kelgoola, County Phillip. Elevation, about two thousand six hundred and thirty-three feet above sea-level. Area, less than one acre. Composition not disclosed. Characteristic shape and forestry.

Dividing Range Volcanic Neck, Sheet 13, Parish Rylstone, County Roxburgh. Situated on the Mount Marsden Range, near the low divide between it and Cumbermelon Range.

Height above sea-level (?)

Area, about six (?) acres.

Composition, olivine-basalt (nepheline).

[6150] and [6152] **Olivine-Basalt** (nepheline-bearing).—Black in colour; fracture hackly. Porphyritic, with somewhat inconspicuous olivine.

Under the microscope are seen corroded phenocrysts of olivine and augite, which seldom show crystal faces. Incipient serpentinization is seen in the olivine. The groundmass consists of augite, microlitic felspar, nepheline, and magnetite.

Fitzgerald's Mount and Ridge, Sheet 13, Parish Mead, County Roxburgh. [4622] Fluidal olivine-basalt flow.[1]

Forest at Head of Dry Swamp Neck, Sheet 14, Parish Kelgoola, County Phillip. Area, about ten acres. Composition, olivine-basalt.

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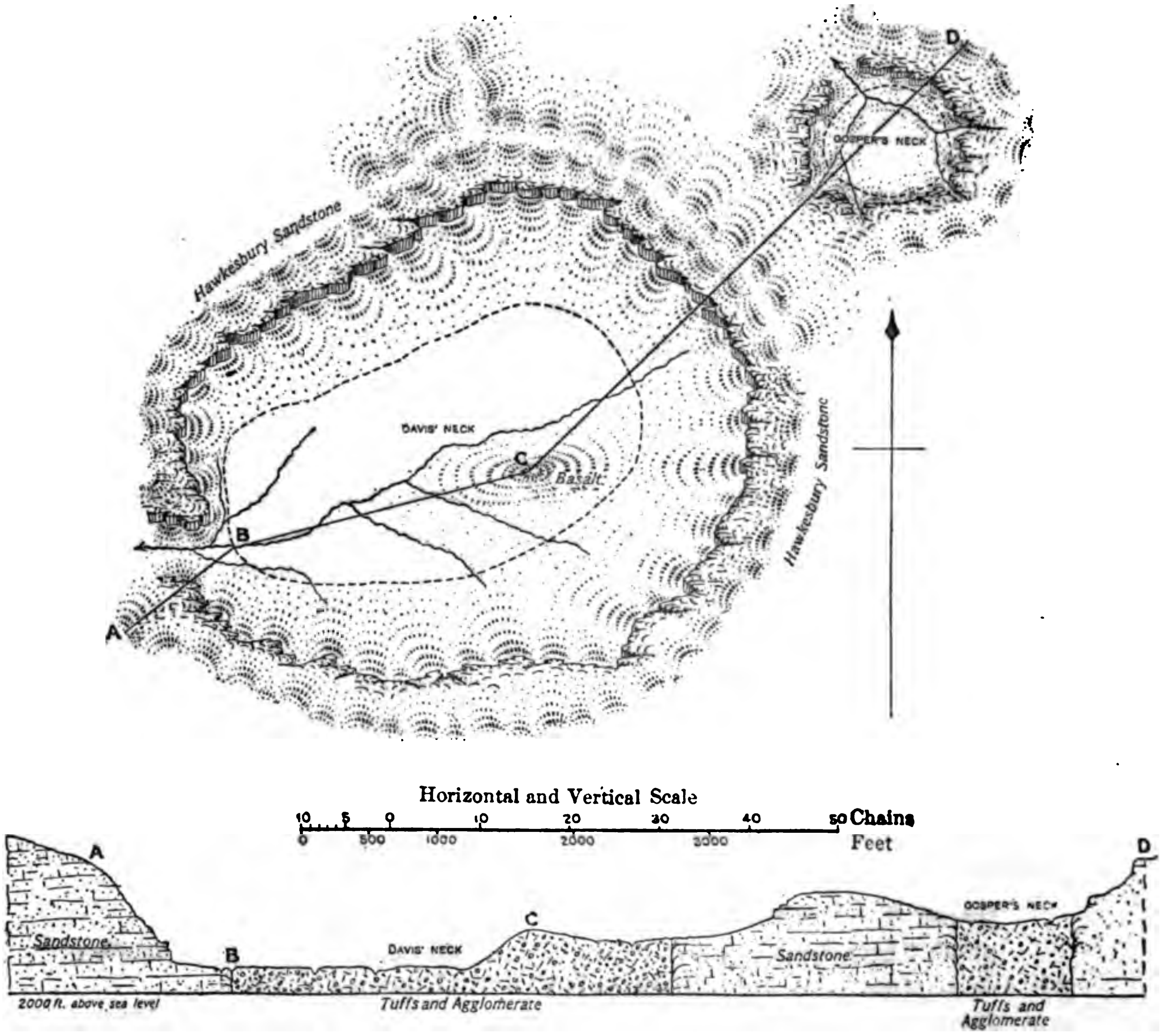
[1] Mem. Geol. Survey N. S. Wales, Geol. 3, 1903, p. 155.

FIG. 6.—DAVIS' AND GOSPER'S HOLES VOLCANIC NECKS.



Diamond Hill Neck, outside and east of Sheet 12, Portion 109, Parish Kurrajong, County Cook. At the apex of an angle formed by junction of Little Wheeny and Blue Gum Creeks. Form roughly circular. Area, about ten acres. Height above sea-level, about six hundred and forty feet. Two-thirds of tuffaceous rim broken down and obscured by denudation, remainder orming wall twelve to fifteen feet in height. Filling partly olivine-basalt, partly tuff. Rim-rock Hawkesbury Sandstone, with Wianamatta Shales capping hill summit. The suggestive name it bears is locally derived from traditional discovery of a diamond at the spot.

[5739] **Olivine-Basalt.**—Porphyritic, with conspicuous crystals of fresh, clearly striated felspar; colour, greyish-black; fracture, hackly.

Under the microscope, large phenocrysts of fresh labradorite, and smaller ones of olivine, are set in a fluidal groundmass of felspar laths, augite, and magnetite. The felspar phenocrysts are externally corroded, and contain numerous stone inclusions, which usually follow the twin planes.

[5739A] is more fine-grained, and contains some glass. The felspar phenocrysts have been deeply invaded by tongues of groundmass, without being otherwise much corroded. Portions of this invading groundmass are clear and spherulitic.

Dingo Forest Neck, Sheet 14, Parish Kelgoola, County Phillip. Elevation, about two thousand six hundred and thirty-three feet above sea-level. Area, less than one acre. Composition not disclosed. Characteristic shape and forestry.

Dividing Range Volcanic Neck, Sheet 13, Parish Rylstone, County Roxburgh. Situated on the Mount Marsden Range, near the low divide between it and Cumbermelon Range.

Height above sea-level (?)

Area, about six (?) acres.

Composition, olivine-basalt (nepheline).

[6150] and [6152] **Olivine-Basalt** (nepheline-bearing).—Black in colour; fracture hackly. Porphyritic, with somewhat inconspicuous olivine.

Under the microscope are seen corroded phenocrysts of olivine and augite, which seldom show crystal faces. Incipient serpentinization is seen in the olivine. The groundmass consists of augite, microlitic felspar, nepheline, and magnetite.

Fitzgerald's Mount and Ridge, Sheet 13, Parish Mead, County Roxburgh. [4622] Fluidal olivine-basalt flow.[1]

Forest at Head of Dry Swamp Neck, Sheet 14, Parish Kelgoola, County Phillip. Area, about ten acres. Composition, olivine-basalt.

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[1] Mem. Geol. Survey N. S. Wales, Geol. 3, 1903, p. 155.

Forest at Head of Left-hand Nile, about one and a half miles south-easterly from Mount Durambang, Sheet 14, Parish Tayar, County Roxburgh. Elevation, about three thousand two hundred and seventy-eight feet above sea-level. Area, about one acre. Composition, olivine-basalt.

Forest above Top Paddock, about two miles north-east of Bald Mount, Sheet 14, Parish Kelgoola, County Phillip. Elevation, three thousand two hundred and twenty feet above sea-level. Area, ten acres. Olivine-basalt.

Forest over Sandy Flat, about half a mile north of Jones' Hole, Main Dividing Range, Sheet 14, Parish Pomany, County Phillip. Elevation, about three thousand two hundred and twenty feet above sea-level. Olivine-basalt. Area, about ten acres.

Gosper's Nob Neck, Sheet 14, Parish Capertee, County Hunter. A small obtuse basalt cone ; approximate height, two thousand four hundred and eighty-five feet above sea-level, and fifty-five feet below neighbouring ridge. Sandstone periphery highly ferruginous at contact. Metallic appearance gave rise to rumoured tin discovery.

[5541] **Nepheline-Basalt.**—A black, platy rock, with moderately conspicuous olivine.

Under the microscope it is microporphyritic, with phenocrysts of olivine and augite in a groundmass of augite, nepheline, magnetite, and felspar. The dominant constituent is augite. The phenocrysts of this mineral are at times automorphic, and are, in part, largely occupied with a plexus of brown glass, through which magnetite is scattered. As a consequence of weathering, a certain amount of iron-staining is shown along the cracks and margins of the olivine phenocrysts. Nepheline is abundant, the numerous little crystals being, for the most part, automorphic. Felspar occurs sparingly in the form of little rods.

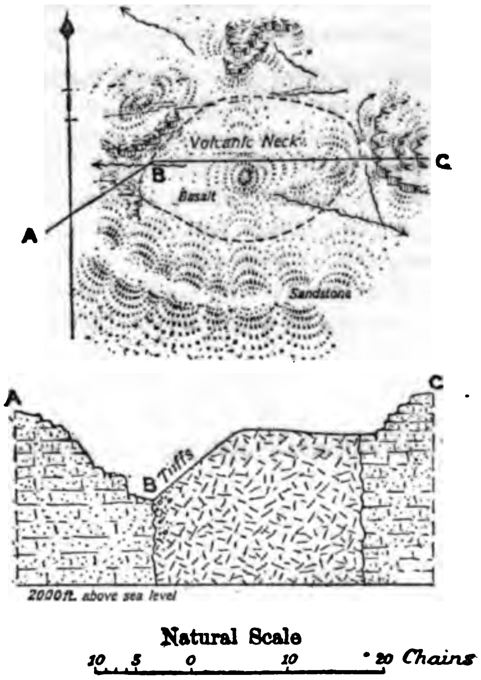
Area of basalt, a quarter of an acre.

Grassy Forest Neck, Sheet 14, Parish Coorongooba, County Hunter, near head of Right Nile. Height, about two thousand seven hundred and ninety-eight feet above sea-level. Summit a few feet only above plateau sandstone, forming dividing ridge between Coorongooba and Wirraba waters. Hollowed out on south side to a depth of three hundred and seventy-five feet by drainage channel, which escapes through cleft in lower sandstone rim cliffs, which have an inward dip of about twenty-five degrees.

Composition, basalt and tuffs.

Area, about seventy-five acres.

FIG. 8.—GRASSY RIDGE NECK, BETWEEN SWAMPY AND GOSPER'S HOLES



Grassy Hill Neck, Sheet 14, Parish Capertee, County Hunter. Within the valley, and on the north bank of Colo or Capertee River, opposite ninety-three-mile peg on Colo Railway Trial Survey.

Bounded by semicircular wall of plateau sandstone cliffs. Filling consists of a central cone of columnar basalt rising about eight hundred feet above the river level, but dominated by the plateau. Peripheral tuffs and coarse agglomerates exposed near river level. Large fragments of Coal Measure and Triassic strata included in agglomerate. Contact with sandstone cliffs which closely approach on west, obscured by talus of basalt and sandstone blocks.

Steep and rugged, owing to horizontal columnar structure, as this volcanic cone is, it affords the only possible ascent to the plateau on the north bank of the river for many miles, owing to height and verticality of cliffs.

Perhaps nowhere in the Blue Mountains are finer or more impressive cliff sections seen than those of the Upper Colo, about Running Stream (Coorongooba) and Grassy Hill.

Composition, fluidal olivine-basalt [**4559**].

Area, about forty acres.

Green Hill, Sheet 12, Parish Barton, County Cook. Elevation, about three thousand three hundred and sixty feet above sea-level. Area of basalt, about ·9 acre. Thickness of exposed columnar basalt, about twenty-five feet.

[6215] **Porphyritic Basalt.**—A greyish-black rock, breaking with a hackly fracture. It is characterised by the presence of numerous conspicuous phenocrysts of fresh labradorite.

Under the microscope the phenocrysts are corroded, and are sometimes largely occupied with a network of glass and stone inclusions. A very distinct outer zone of different composition is often present. Albite and Carlsbad twinning are present, and permit of the identification of the felspar species as Ab_1, An_1. Some olivine and serpentine are present. The groundmass is sub-fluidal, and consists of labradorite, magnetite, and augite. Certain large masses of magnetite are seen; these are fringed with magnetite granules, and the whole may have been so built up. Enclosed is a fragment of a medium-grained crystalline rock, consisting of enstatite (schillerized) and plagioclase.

Green Hill Neck, Sheet 14, Stony Creek, Parish Kindarun, County Hunter. Elevation, about one thousand five hundred and twenty feet above sea-level. Small cone rising about one hundred feet above surrounding Hawkesbury Sandstone. Area, about five and a half acres.

[5557] **Olivine-Basalt.**—Greyish and bluish black in colour, fracture uneven. Olivine is abundant, sometimes occurring as conspicuous masses.

Under the microscope, olivine is abundant and fresh, the phenocrysts being at times amorphous, at others automorphic. Porphyritic augite is scarce, but automorphs do occur. It is green in colour, with a violet border. The groundmass is dense and highly augitic; felspar and magnetite being subordinate in amount.

Green Hill Flow (?) east of Sheet 14, Parish Bulga, County Hunter, near Blackfellow's Arm. Elevation, about one thousand two hundred and seventy feet above sea-level. Small basalt nob on Hawkesbury Sandstone, probably portion of flow. Area, about one and a half acres.

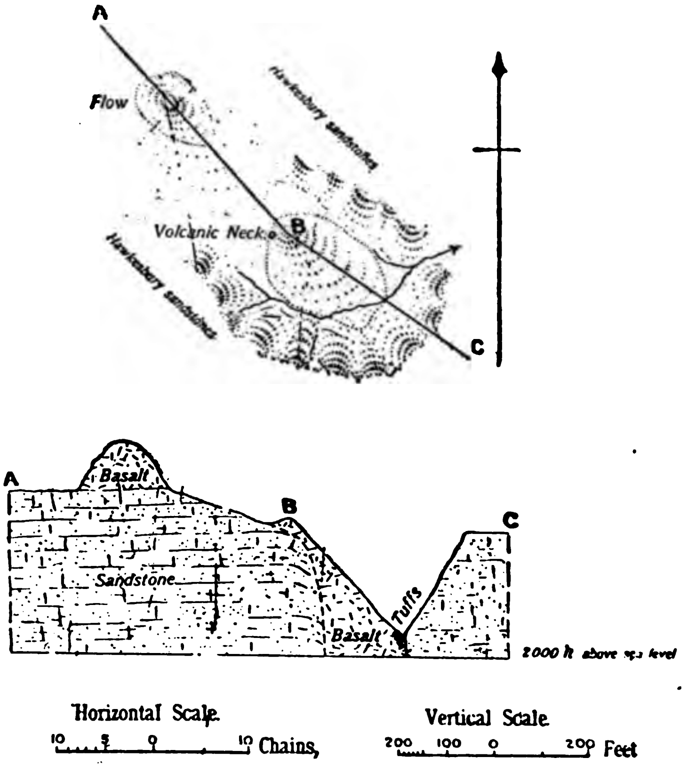
Green Hill Neck and Flow, Sheet 14, Parish Capertee, County Hunter. Elevation of hill, about two thousand six hundred and thirty-five feet above sea-level; thickness of flow basalt, about one hundred and ten feet. Area, about twelve acres.

The neck lies about ten chains south-easterly from Green Hill. Denudation has removed previous connections. Highest exposure of neck in plateau sandstone, two thousand four hundred and eighty-five feet; lowest, two thousand two hundred and forty feet above sea-level. Tuffs exposed in small channel dissecting neck. Composition of filling, basalt and tuffs. Well-grassed, open forest.

[5545] **Olivine-Basalt.**—A greyish-black rock, breaking with a somewhat platy fracture.

Under the microscope it is seen to closely resemble the basalt from Mount Wirraba. Phenocrysts of olivine and labradorite lie in a fluidal groundmass of felspar, augite, and magnetite, The felspar crystals are all highly elongated, and share in the fluxion. Olivine is slightly serpentinized. Magnetite is abundant as tiny scattered crystals.

Fig. 9.—Green Hill Volcanic Neck.



Gulph Neck, Sheet 13, Parish Growee, County Phillip, partly enclosed in Portions 129 and 130, on Rylstone-Bylong road. An extensive volcanic neck, intersected by Gulph Creek to a depth of over nine hundred and fifty feet below its conical summit, near the north-west portion of rim, which reaches an elevation of about two thousand six hundred and fifteen feet above sea-level. About three parts of circumference dominated by bold vertical cliffs of Hawkesbury Sandstone. On the east and north-east, a high thin wall of this rock separates the neck from Growee Creek Valley, which lies one thousand three hundred and sixty-five feet below the neck summit, and four hundred and ten feet below its lowest exposure in Gulph Creek. Two dykes are exposed in the wall-face on the Growee side, following jagged vertical fractures, and connecting with the neck. Upper Coal Measures are exposed close to contact in Gulph Creek. Hawkesbury Sandstone highly vitreous where contact is exposed.

[5224, 5936, 6148, 6149] Olivine-Basalt.—Colour, dark greenish-black; texture, almost doleritic; fracture, uneven to lumpy. Olivine is occasionally distinctly visible, but cannot be called porphyritic. A small amygdale can be seen occasionally. The rock is not calcareous.

Under the microscope, the rock is quite fresh. It is abundantly olivinic, and contains, in addition to olivine, plagioclase, augite, and magnetite. The olivine, which is quite fresh, shows a slight tendency to become porphyritic; it also shows, now and then, an indication of crystal form. From the extinctions, the plagioclase appears to be near $Ab_2 An_3$. It is the dominant mineral, and occur as laths, varying in length up to a millimetre, and showing a distinct tendency to orientation. The augite is granular, and slighly pleochroic, with pale shades of brown and violet. Magnetite is comparatively scarce, Harber's Forest Neck, Sheet 14, Portion 53, Parish Coolcalwin, County Phillip. Elevation, about two thousand four hundred and sixty feet above sea-level. Open forest country. Composition not disclosed.

Head of Round-topped Arm Neck, Sheet 14, Parish Gullongulong, County Hunter. Elevation, about one thousand two hundred feet above sea-level. In Hawkesbury Sandstone. Area, about 1·2 acre.

[5823] **Olivine-Basalt** (doleritic).—Greyish-black in colour, weathering crusts lighter than usual with basalts. Small phenocrysts of augite are readily visible, without being conspicuous; olivine can also be seen.

Under the microscope, porphyritic masses of brown and purple augite lie in a sub-ophitic groundmass, consisting of elongated crystals of plagioclase, granular augite and olivine, and magnetite, in scattered masses of considerable size. A secondary material, yellowish in colour and feebly isotropic, is fairly common.

Head of Swampy Arm Neck, (?) east of Sheet 14, Parish Tupa, County Hunter. Elevation, about one thousand feet above sea-level. In Hawkesbury Sandstone. Exposed on side of valley. Exact nature of occurrence not ascertained. Area, ·8 acre.

[5817] **Olivine-Basalt.**—Colour, dull black; fracture, hackly. Olivine is conspicuous, in masses up to fifteen millimetres in length, and augite can also be detected.

Under the microscope, augite and olivine are seen as phenocrysts. The former affords excellent instances of regrowth (Fig. 1). The added material shows considerable crystallographic form; it is fresher than, and may extinguish at a somewhat different angle to, the nucleus. Olivine is in irregular fragments, and has undergone some serpentinization. The groundmass is dense and rather obscure; it contains microlitic laths of felspar, which are fluidally disposed, and much pigmental magnetite.

FIG. 11.

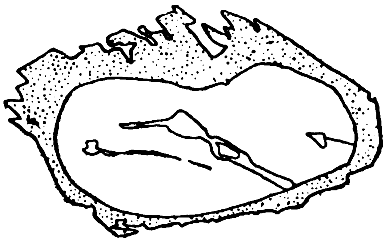


Fig. 1

Augite showing a zone of new material (dotted). From Olivine-Basalt, Swampy Arm, Putty. Slide 2,744.

Jacob's Hollow Clear, Sheet 14, Parish Tupa, County Hunter. Elevation, about one thousand one hundred and fifteen feet above sea-level. Composition obscured. Open white box forest (*E. albens*), or its coastal variety, *E. hemiphloia*, circular hollow, well-grassed; surrounded by sandstone country.

Jonathan's Nob Flow, Sheet 14, Portion 1, Parish Six Brothers, County Hunter. Elevation, about two thousand two hundred and seventy feet above sea-level. About three and a half miles east of junction of Wollemi Creek and Colo River. Area, about forty-five acres.

Low Forest Flow, Sheet 14, Parish Tayar, County Roxburgh. Elevation, about three thousand and sixty feet above sea-level. Area, about ten acres. Olivine-basalt.

Marsden's Arm Neck, east of Sheet 14, Parish Gullongulong, County Hunter. Elevation, about one thousand one hundred and thirty-five feet above sea-level. In Hawkesbury Sandstone. Situated in low saddle of ridge. Filling, basalt surrounded by tuffs. Western sandstone rim dips inward at thirty-two degrees. Eastern broken down on fall to Marsden's Arm. Area, ·4 acre.

[5818] **Olivine-Basalt.**—Dull black in colour; fracture hackly. Olivine is conspicuous (in masses varying in dimension up to 15 millimetres), and augite is also visible.

Under the microscope the phenocrysts are seen to be olivine and augite. Those of augite afford excellent illustrations of regrowth. The added material is fresher than, and may extinguish at a different angle to, the nucleus, and also develops considerable crystal-form. Olivine is in irregular fragments and is somewhat serpentinized. The groundmass is fine-grained and rather obscure. It shows many areas quite black with magnetite, and also contains clear isotropic portions. Partially assimilated fragments of sandy claystone are included.

[5819] **Ferruginous Volcanic Tuff.**

Mead's Hill Neck, Sheet 14, Parish Kelgoola, County Phillip. Elevation above sea-level, about two thousand eight hundred and eighteen feet. Area, about five acres. Forms a low hill near Dunn's Mount Homestead, with steep fall to Ganguddy Creek. Basalt and tuffs filling on a level with denuded sandstone rim; the latter well defined and vitrified.

[5842] **Olivine-Basalt.**—A black, rather platy rock. Olivine is abundant, and sometimes conspicuous.

Under the microscope the texture is porphyritic, with irregular masses of more or less completely serpentinized olivine. The groundmass is a very fine-grained admixture of augite, felspar, and magnetite.

Mill Forest Necks, Sheet 14, Parish Kelgoola, County Phillip, north-east of Mead's Hill. Elevation, about two thousand five hundred and sixty-three and two thousand seven hundred and thirty-three feet above sea-level respectively. Area, ·5 and five acres. Composition, olivine-basalt.

Moen Neck, east of Sheet 14, Parish Burton, County Northumberland. Area, about twenty acres. Elevation, about eight hundred and seventy feet above sea-level and one thousand and sixty-four below the summit of Mount Wareng (about four miles west), and one thousand two hundred and ninety-four feet below Mount Yengo (about eight miles south twenty-five degrees west).

Forms a well-grassed, open-timbered valley in Hawkesbury Sandstone. Huge masses of coarse agglomerate occur in this neck, possessing a very slaggy appearance, indicative of rapid cooling. Composition, olivine-basalt, with basalt glass.

Neck surrounded by lower edge of sandstones close to rim, then by high ranges, forming the valley of Moen Creek.

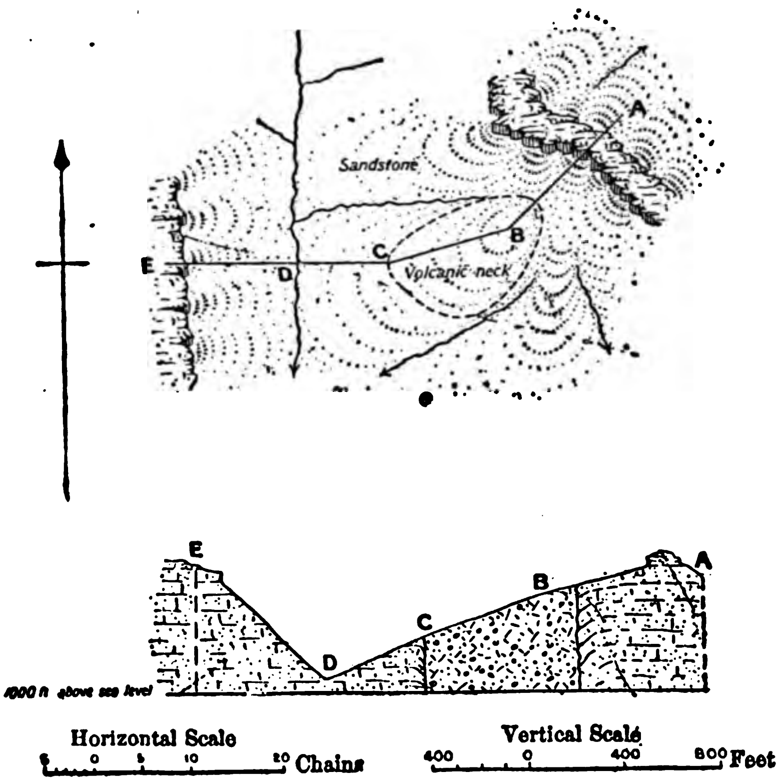
[5556] **Olivine-Basalt.**—Greyish-black in colour, and thickly speckled with red olivine. The texture is aphanitic, the crystalline character being just discernible with a lens.

Under the microscope granular olivine is embedded in a groundmass of plagioclase (laths), augite, and magnetite. The rock is considerably weathered, with resultant iron-staining.

[5556A] **Basalt Agglomerate.**—The agglomerate contains fragments of basalt-glass. When unaltered the glass is yellow and perfectly isotropic, but alteration produces a soft opaque material of a deeper yellow.

Under high magnifying powers the glass is structureless. It is thickly studded with phenocrysts of olivine, augite, and felspar. Other lapilli are almost black with much dark pigment; their groundmass is devitrified, and contains numerous microlites of felspar.

FIG. 12.—MOEN VOLCANIC NECK.



Mount Banks or Mount King George, Sheet 12, Parish Irvine, County Cook. Trigonometrical substation. Approximate height, three thousand three hundred and ninety feet above sea-level. Situated on north bank of Grose Valley.

Ascended by G. Caley in 1804. Named by him "Mount Banks," in honor of Sir Joseph Banks. Renamed "King George" by Surveyor-General Mitchell, in his Map of New South Wales, published in 1834.

The summit is formed of a thin remnant of an olivine-basalt flow, apparently resting on Hawkesbury Sandstone westerly, on Wianamatta Shales south-westerly and easterly; maximum thickness of latter, about fifteen or twenty feet.

Southern cone is separated by denudation from main mass; apex, about thirty feet lower.

Noticeable feature, horizontal lamination in rudely columnar structure of basalt, similar to Waterfall basalt of Mount Wilson. Probably arising from successive extrusions of very fluid lava.

Topographically surveyed by Govett in 1832. Ascended by Strzelecki in 1839.

[5294] **Olivine-Basalt.**—Greyish-black in colour. Texture very compact; fracture, even to subconchoidal. Grassy-green blebs of olivine are readily seen. A few little vesicles, lined with zeolitic matter, are present.

Under the microscope the groundmass is holocrystalline, but indistinct. Slight fluxion is indicated by the disposition of the felspar microliths. Olivine seldom shows crystal edges; it is only slightly serpentinized. Magnetite is conspicuous and abundant.

Area of basalt.—Main mass, about twelve acres; small southern nob, about two and a half acres.

Mount Baker Flow, Sheet 14, Parish Nullo, County Hunter. A small area of basalt, south of Kerry Mount, probably part of same flow.

Mount Bell, Sheet 12, Parish Irvine, County Cook. Approximate height, three thousand two hundred feet above sea-level.

Ascended by G. Caley, Botanist, in 1804. Named by him "Table Hill." Renamed "Mount Bell" in 1834 by Surveyor-General Mitchell, in honor of A. Bell, of Belmont, whose stock route wound round its northern and western slopes.

Capped over an area of about thirty acres with about fifty feet of olivine-basalt. Connected with Mount Tomah by a narrow bridge of Hawkesbury Sandstone.

[5296] **Olivine-Basalt.**—A black, porphyritic rock, breaking with an uneven fracture. The phenocrysts are small and numerous, consisting of striated felspar and olivine.

Under the microscope, phenocrystalline augite is also seen. The phenocrysts are strongly corroded, those of felspar often having the central area crowded with ramifying glass inclusions. The felspar species appears to be labradorite, with sometimes an outer zone of less basic material, free from inclusions. Augite is also crowded with inclusions, and is itself enclosed by the felspar. The groundmass is somewhat dense. It shows slight indications of fluxion round phenocrysts. Magnetite is abundant, and there is considerable iron staining.

Springs on eastern margin indicate superficial flow. Lowest exposure of basalt, in drainage channel, on western margin, five hundred and twenty-five feet below summit. May be filling pre-basaltic channel, or part of neck; evidence not conclusive.

Area of basalt, about two hundred and thirty acres.

The basalt and enriched lower area embrace about four hundred acres of excellent grazing and agricultural land; which was secured by two settlers—W. C. Wallace and J. G. Beecroft, in 1903—though J. H. McLean held Portion 1 in 1890, but forfeited it in 1894.

[6217] **Olivine-Basalt.**—A black rock, somewhat platy, breaking with an uneven fracture. Olivine is discernible.

Under the microscope, it shows a fluidal groundmass with small phenocrysts of somewhat serpentinized olivine. The groundmass is highly fluxional and fine-grained, with abundant elongated crystals of plagioclase. It is rather dense, with much pigmental magnetite. No glassy base has been detected.

Mount Coorongooba, Sheet 14, Parish Coorongooba, County Hunter. A prominent symmetrical cone above plateau sandstone level, on Main Dividing Range. Elevation, about three thousand six hundred and ninety-five feet above sea-level. Well grassed, open forest country. Over five hundred feet of basalt above sandstone. Mode of occurrence not ascertained. Area, about one hundred and fifteen acres.

[5858] **Nepheline-Basalt.**—A black rock, breaking with a very uneven, lumpy fracture. Olivine is abundant, and sometimes forms large masses.

Under the microscope the phenocrystalline olivine is seen to be but slightly serpentinized. The grains are of varying size, and are usually highly irregular, but an automorph is occasionally seen. The groundmass is fine-grained, consisting of prismatic and granular augite, with nepheline and magnetite. Tiny crystals of magnetite are generally distributed, and are enclosed in olivine. The slide shows an area of granular olivine, with scattered magnetite. There is also an area of crypto-crystalline material surrounded with a mantle of granular olivine and specks of magnetite; this appears to be an altered inclusion of foreign material.

Mount Coriaday, Sheet 14, Parish Nullo, County Hunter, locally known as "Little Kerry." A most interesting volcanic neck, forming a symmetrical cone. About two hundred and fifty feet below its summit, a rim of coarse agglomerate occurs. Coriaday rises about five hundred and ninety-five feet above the sandstone plateau level, with a height above sea-level of about three thousand nine hundred and fifty feet. Area, about seventy-five acres.

[5880] **Olivine-Basalt** (nepheline-bearing and doleritic).—A black, jointed rock, breaking with a very uneven (almost hackly) fracture. Some small masses of olivine are visible, and the crystalline character is discernible under a lens.

Under the microscope the presence of much olivine, in the form of irregular masses, renders the rock microporphyritic. The augite is granular and fresh; the felspar is a basic species of labradorite; magnetite exists as scattered granules; nepheline is revealed in the groundmass by staining.

Mount Darcy, Sheet 14, Parishes Kelgoola and Coorongooba, County Phillip, on the Main Dividing Range. Approximate height above sea-level, three thousand six hundred and thirteen feet. Basalt crown rising about one hundred and fifty feet above sandstone base. Area about forty acres.

[5864] **Olivine-Basalt** (analcitic).—Much olivine and augite are visible in small masses. The fracture is very uneven.

Under the microscope, phenocrysts of augite and olivine lie in a fine groundmass containing a clear isotropic base. The augite crystals are often perfectly automorphic. One crystal showed a green nucleus extinguishing at a different angle to the peripheral area. Olivine is fresh, with but little iron-staining and serpentinization. Corrosion by groundmass has led to the introduction of stone inclusions. The groundmass consists of augite, isotropic base (analcite), felspar, and an abundance of pigmental magnetite.

Mount Davis' Neck, Sheet 14, Parish Pomany, County Phillip. Height above sea-level, about three thousand four hundred and seventy feet. Sandstone rim on north within forty feet of summit, rising northerly to greater elevation. Southern rim broken down about two hundred and fifty feet. Area, about twelve acres; well grassed.

[5883] **Olivine-Basalt** (nepheline-bearing).—Colour, black; fracture, hackly. Olivine is abundant and conspicuous. The texture is aphanitic, but almost permits of a resolution of the groundmass with a lens.

Under the microscope, phenocrysts of augite may be seen, in addition to those of olivine. Those of olivine show slight staining along cracks, but are otherwise fresh. They are more or less automorphic, but have been much corroded. The augite phenocrysts are less numerous. They are brown in colour, and have also been much corroded, being sometimes crowded with glass inclusions. Marginal zoning is occasionally shown. The groundmass is distinctly holocrystalline. It consists essentially of augite, felspar, nepheline, and magnetite.

Mount Durambang (or Dunn's Mount), Sheet 14, Parish Ganguddy, County Roxburgh. A large domed mountain, having an elevation of about three thousand eight hundred and fifty feet above sea-level at its highest point. Situated on Main Dividing Range. Exact nature, whether flow or neck, not ascertained. Dominates plateau sandstone by several hundred feet on south and west, but latter rises high on north and east. Area, one hundred and thirty acres.

[5872] **Olivine-Basalt.**—A greyish-black, jointed rock, with even or sub-even fracture. The texture is approximately doleritic, the mineral components being readily distinguishable with a lens—particularly is this so with olivine.

Under the microscope the texture is microporphyritic, with much olivine, and some augite and magnetite, embedded in a groundmass of augite and felspar, with magnetite in places. Olivine is fresh, with but slight serpentinization; the crystals are often automorphic, but are corroded. The groundmass is distinctly holocrystalline, consisting essentially of granular augite and laths of plagioclase. Stout crystals of apatite are also present. An area consisting entirely of granular augite was noticed.

Mount Graham Neck, Sheet 13, Parish Growee, County Phillip. On the Main Dividing Range. Forms small cone about fifty feet above Hawkesbury Sandstone range. Western rim high up on shoulder and confined to a few chains circumference. Eastern border broken down by Jumper Creek Valley to a depth of about seven hundred feet. Slope of

Mount Irvine has been secured by several graduates of the Hawkesbury Agricultural College, and fruit trees, vegetables, and corn are replacing the erstwhile dense jungle forest of giant eucalypts, with vines, ferns, and other undergrowths.

Near Scrivener's Farm a perennial spring emerges from a section of an early drainage channel beneath the basalt. The channel-drift consists of well-worn boulders and pebbles of quartzite, quartz, and slate,—materials which must have been transported from the western margin of the original coal basin, probably from the high Devonian quartzite range between Mount Lambie and Sunny Corner.

The thickness of the basalt above the channel is about three hundred feet, becoming correspondingly thinner to the west, where the Hawkesbury Sandstone rises at least one hundred and fifty feet higher than on the east.

It is possible that gold occurs in this old channel-drift, but its area is insignificant.

[5292] **Olivine-Basalt.**—A vesicular and amygdaloidal rock, with small, opaque, white, round or elliptical amygdales. At times the vesicles are merely lined with secondary material. Olivine, felspar, and augite form inconspicuous phenocrysts, the rock being otherwise quite aphanitic. The microscopic characters are identical with those of the Mount Wilson basalt.

Mount Kelgoola Neck, Sheet 14, Parish Kelgoola, County Phillip. A very symmetrical and conspicuous cone, with basalt blocks resting on a steep angle of slope, like talus. Elevation of cone, about three thousand seven hundred and seventy-eight feet above sea-level. Dominates sandstone plateau level by about four hundred feet. Area, about one hundred and five acres.

[5869] **Olivine-Basalt** (analcitic).—Black in colour, with plentiful conspicuous masses of olivine. The fracture is very uneven.

Under the microscope the texture is microporphyritic, with phenocrysts of fresh (or slightly serpentinized) olivine in a groundmass of augite, plagioclase, magnetite, and isotropic base. The isotropic material (analcite) is sometimes replaced by a dusky yellow, very feebly polarizing substance. Long needles of apatite are common.

Mount Kindarun Necks, Sheet 14. Situated on spur of Main Dividing Range, between waters of Hunter and Colo Rivers, about the boundary of Parishes Myrtle and Kindarun, County Hunter.

Elevation of highest peak, about two thousand six hundred feet above sea-level.

Area, about thirty-eight acres.

Three necks occur in close proximity. Plateau sandstone rim reaches within about seventy feet of top of main neck on west. Eastern rim broken

Mount Kindarun (No. 3 Neck).

[5812] **Olivine-Basalt.**—Colour, greyish-black; fracture uneven. Small phenocrysts of fresh, green olivine are abundant.

Under the microscope, phenocrysts of light brown augite are also visible, but in less abundance than olivine. The phenocrysts are often corroded, those of augite being occasionally perfectly automorphic. Olivine shows very slight alteration along cracks. The augite may be crowded with stone inclusions. The groundmass consists of tiny microlites of fresh plagioclase—which show a tendency to stream round the phenocrysts—with minute granules of augite and magnetite.

Mountain Lagoon Neck, east of Sheet 12, Parish Wheeny, County Cook. About one and a quarter miles south of Conder Trigonometrical Station, on western slope of spur between Mountain Lagoon and Wheeny Creeks. Superficial area small. Eastern margin dominated by Hawkesbury Sandstone; western exposed by denudation to a depth of four hundred feet.

Actual contacts obscured by *débris*. Small tributary of Mount Lagoon Creek, descending western slope, exposes several massive superposed outcrops of almost horizontal basalt columns; inclination probably denoting lateral cooling surfaces, *i.e.*, neck walls.

Highest exposure above sea-level, about one thousand nine hundred and forty-five feet; lowest, about one thousand five hundred feet.

[5538] **Ophitic Olivine-Dolerite.**—Olivine is present in abundance. It is fresh, somewhat corroded, and not infrequently automorphic. Plagioclase is also fresh, and forms elongated crystals. Augite is violet, where fresh, but is for the most part converted into a dull greyish product, often containing numerous crossing rods of rutile or iron ores. Magnetite occurs as conspicuous rods.

Mount Midderula, Sheet 14, Parish Kelgoola, County Phillip. Occupies the central position of the three most conspicuous adjacent cones in Parish Kelgoola. Elevation of top of cone, about three thousand three hundred and ninety-three feet above sea-level. Exposed base of basalt about three hundred feet lower. Dominates the sandstone plateau level. Exact nature of occurrence not ascertained; may be neck. Area, about twenty-eight acres.

[5873] **Dolerite-Porphyry** (nephelinic).—This rock is of a rather unusual character. Weathered surfaces present a notable appearance, abundant small phenocrysts of black augite standing out in relief upon them. The texture of the groundmass is doleritic, and on a weathered joint face the mineral constituents—augite, plagioclase, olivine, and magnetite—can be easily distinguished. The fracture varies from even to very uneven. Olivine is readily discerned on a freshly fractured surface.

Under the microscope the phenocrysts of augite are very conspicuous and abundant. They are fresh, well cleaved, sometimes perfectly automorphic, show composition-zoning well, and are decidedly pleochroic—violet to yellow-brown. The pleochroism is at times more intense marginally. Some twinning is present, and there is occasionally an inconspicuous penetration by felspar. Olivine and magnetite are enclosed. Olivine is also plentiful, and quite fresh, save for some staining along cracks. Plagioclase may attain phenocrystalline dimensions, but principally occupies the space between the phenocrysts as a sort of groundmass together with nepheline and some augite. The plagioclase appears to be a basic labradorite.

Another type **[5873A]** of this rock resembles it in mineral constitution, but the grain-size is approximately even. Weathered surfaces do not show the augite crystals.

The chemical composition is as follows :—

	Weight percentage.	Molecular ratio.
SiO_2	45·25	·754
Al_2O_3	15·13	·148
Fe_2O_3	1·80	·011
FeO	8·82	·122
MgO	10·24	·256
CaO	10·98	·196
Na_2O	3·36	·055
K_2O	1·22	·013
H_2O (100° C)	0·09	...
H_2O (100° C+)	1·21	...
CO_2	0·06	...
TiO_2	1·52	·019
ZrO_2	none.	...
P_2O_5	0·52	·004
SO_3	none.	...
Cl	trace.	...
S (FeS_2)	none.	...
Cr_2O_3	0·01	...
NiO, CoO	none.	...
CuO	trace.	...
MnO	0·07	...
BaO	0·03	...
SrO	trace.	...
Li_2O	none.	...
V_2O_5	0·03	...
	100·34	

Analysis, by Harold P. White.

Specific Gravity, 3·014.

The norm, calculated from this analysis, is as follows :—

Orthoclase	7·23
Albite	9·96
Anorthite	22·24
Nepheline	10·22
Diopside	23·11
Olivine	19·13
Magnetite	2·55
Ilmenite	2·89
Apatite	1·34

In the Quantitative System, the rock would be classified as **Limburgose.**

Mount Molong (also known as Simmond's Mount, after holder of Portion 5), Sheet 14, Parish Wolgan, County Hunter.

There is no doubt of the identity of the two, though the former is shown on the parish map some distance from the measured portion on the basalt area. A sample of rock, collected by Surveyor P. G. Ogilvie, from "Mount Molong, on range north of Colo River," was identified by Lonsdale as basalt.[1]

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[1] Mitchell's Report, Oct. 16, 1851, p. 12.—Gold Discovery Papers, Vol. I.

Height above sea-level, about two thousand six hundred and thirty feet. Basalt rises about one hundred feet above surrounding country. Undetermined whether neck or flow. Area, about one hundred and sixty acres.

About thirty chains north of Mount Molong, in the Parish of Innes, is a small outlier of basalt, having a thickness of about one hundred feet above sandstone. Area, about thirty acres.

[5542] **Trachytic Basalt** (nephelinic).—Colour blackish-green, fracture splintery and sub-conchoidal. Texture aphanitic, an occasional small crystal of felspar and a grain or two of olivine being visible.

Under the microscope the groundmass is essentially felspathic. In it lie scattered, irregular fragments of olivine and augite, and an abundance of magnetite—in small grains for the most part, but also as larger masses. Some serpentinization has taken place. Here and there are conspicuous stout crystals of purplish apatite.

The felspar shows low double refraction, but appears to be striated for the most part, and to have an index of refraction greater than that of the balsam; it is, therefore, essentially plagioclastic. From the analysis which succeeds, it is evident that nepheline is present in some quantity. The comparative scarcity of augite marks this rock off from ordinary basalts. The specific gravity is 2·8.

The chemical composition is as follows:—

	Weight percentage.	Molecular ratio.
SiO_2	49·82	·833
Al_2O_3	17·53	·172
Fe_2O_3	4·30	·027
FeO	7·11	·099
MgO	3·02	·075
CaO	5·26	·094
Na_2O	5·90	·095
K_2O	2·55	·027
H_2O (100° C)	0·30	...
H_2O (100° C+)	1·31	...
CO_2	0 04	...
TiO_2	2 04	·025
ZrO_2	none	...
P_2O_5	0·88	·006
SO_3	none.	...
Cl	0·04	...
F	?	...
S (FeS_2)	none.	...
Cr_2O^3	trace.	...
NiO, CoO	none.	...
CuO	none.	...
MnO	0·15	·002
BaO	0·03	...
SrO	trace.	...
Li_2O	none.	...
V_2O_5	trace.	...
O = Cl	100·28	
	0·01	
	100·27	

Analysis of
Trachytic Basalt,
Mount Simmonds,
by
Harold P. White.

Specific gravity, 2·81.

The norm, calculated from this analysis, is as follows—

Orthoclase	15·01
Albite...	36-15
Anorthite	13·90
Nepheline	7·38
Diopside	5·94
Olivine	7·94
Magnetite	6·26
Ilmenite	3·80
Apatite	2·02

By the Quantitative System, the rock would be classified as II, 5, 2, 4, under the name of **Akerose.**

Mount Monundilla, Sheet 14, Parish Monundilla, County Hunter. Elevation about three thousand six hundred and seventy-five feet above sea-level. Thickness of basalt, about one hundred and twenty-five feet. Apparently part of flow. Chocolate shales exposed at two thousand seven hundred and seventy-five and two thousand nine hundred and fifteen feet levels on west side. Large forest timber, little grass. Area, about twenty-five acres.

[5881] **Olivine-Basalt** (doleritic).—Colour greenish-black, fracture highly irregular, texture doleritic. Olivine is visible.

Under the microscope it is seen to be highly felspathic, plagioclase being the dominant mineral. In this respect it differs much from the great majority of the rocks of this series. The plagioclase is a labradorite of moderate basicity. Olivine is quite fresh, merely showing iron-staining in places. The augite is purple, but not pleochroic; it has a distinct fibrous structure. Considerable separation of iron ore has taken place within the augite, but is not accompanied by any appreciable degree of bleaching.

Mount Morundurey, Sheet 14, Parish Morundurey, County Roxburgh. A small patch of olivine-basalt overlying drift has been found on the summit of this Hawkesbury Sandstone Mountain, east of the Village of Airly, and near Airly Turret.

Gold has been worked in the drift,[2] which constitutes part of an old drainage channel; probably a continuation of that noticed under the basalt of Black Mountain, at the north end of Airly Mount.

Mount Muruin (Mount Shivering), for comparison.—Parish Tartarus, County Westmoreland.

Trigonometric station, height, three thousand six hundred and seventy-eight feet above sea-level. Between The Peaks and Mount Werong.

[5226] **Quartz-Porphyry.**—Abundant phenocrysts of quartz and felspar, occupying together about one-half the volume of the rock, are imbedded in a grey base. Those of quartz average from 2 mm. to 3 mm. in diameter. Those of felspar are automorphic; the crystals are opaque-white in colour, sometimes show simple twinning, and vary in length up to 10 mm.

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[2] See page 248.

Under the microscope the groundmass is crypto-crystalline, with a tendency to become micro-granitic in places. The quartz phenocrysts are corroded, but crystal outline is not obliterated. The felspar is turbid from alteration, but appears to be mainly orthoclase. Both quartz and felspar—but more particularly the latter—display dislocation, which is sometimes accompanied by interruption of optical continuity. As accessories, iron oxide, magnetite, a little apatite, and, perhaps, zircon occur.

[5708] **Nepheline-Basalt.**—This rock is closely similar to that capping the neighbouring eminence known as the Peak, which has recently been described.[1] One crystal of felspar was detected.

Mount Never Never, Sheet 14, Parish Never Never, County Phillip. A long narrow basalt-capped mountain, having an elevation of about three thousand nine hundred and ten feet above sea-level at its highest point. The Hawkesbury Sandstone rises to within about five hundred feet of the highest point on the north-west end. Northerly, the basalt talus runs down to at least five hundred feet lower. It is probable that a vent occurs here, but sufficient evidence was not obtained to determine. Well-grassed, open forest land. Area, four hundred acres.

[5874] **Olivine-Dolerite.**—A black rock, breaking with a lumpy fracture. The mineral components, including olivine, are readily discerned.

Under the microscope, the rock consists of an even-grained admixture of violet augite, labradorite, olivine, and magnetite. It is quite fresh. The magnetite is enclosed by, or attached to, augite almost exclusively; it occurs as rods, irregular masses, and minute crystals.

Mount Nullo, Sheet 14, Parish Nullo, County Hunter, near Mount Coriaday. Height above sea-level, about three thousand four hundred and twenty feet. Sandstone rim rises to within ninety-five feet of summit on north, broken down on south to a depth of three hundred and twenty feet. Area, about twelve acres.

[5888A.] **Nepheline-Basalt.**—A bluish-black rock, breaking with a hackly fracture. Olivine is visible, and may form large masses.

Under the microscope the rock is micro-porphyritic, with abundance of olivine. The mineral shows slight serpentinization along cracks. The groundmass consists of granular augite, much dusky, barely translucent material, and magnetite. With the dusky material is intermixed some feebly double refractive clear mineral; the whole of this is regarded as nepheline, in large part altered, but its exact nature remains to be determined. Felspar cannot be identified with certainty.

Mount Pomany, north of Sheet 14, Parish Widdin, County Phillip. On west bank of Widdin Brook. Height, about three thousand seven hundred feet above sea-level. Thickness of basalt on west side, about four hundred and fifty feet. May be a point of eruption; evidence not conclusive.

Pomany forms the highest and most conspicuous peak on northerly trending ridge between Widdin Brook and Emu Creek.

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[1] Records Geol. Survey N. S. Wales, VII, 3 (1903), p. 236.

Advantage has been taken of its well-grassed summit and slopes by an enterprising settler as a sheep run. Approachable only by following the water parting from Nullo Mountain on the south, or the Goulburn River on the north. At the head of Hool-em-boy Creek, the width of the ridge permits of a narrow bridle-track only. At this point a small typical volcanic neck occurs.

[5882] **Olivine-Basalt** (nepheline-bearing).—Greyish-black in colour, breaking with a sub-conchoidal fracture. Olivine is rather plentiful.

Under the microscope it shows augite, olivine, plagioclase, nepheline, and magnetite. Plagioclase is in tiny twinned crystals; magnetite in sparsely scattered grains. Nepheline is of local occurrence. Olivine is at times in well-developed crystals.

Mount Poppong, east of Sheet 14, Parish Poppong, County Hunter. Trigonometrical station. Height, one thousand eight hundred and sixty-five feet above sea-level. Thickness of basalt above highest exposure of sandstone, about three hundred and forty-five feet. Undetermined whether neck or flow. Well grassed; secured for settlement.

[5558] **Olivine-Basalt.**—Greyish-black in colour; fracture lumpy. Olivine is plentiful, sometimes forming conspicuous masses.

Under the microscope corroded olivine crystals are abundant; they show slight alteration along cracks only. The groundmass is clear and distinctly holocrystalline; it consists of augite, felspar, olivine, and magnetite.

Mount Tomah, Sheet 12, Parish Irvine, County Cook. Trigonometrical station three thousand two hundred and seventy-six feet above sea-level.

Ascended first by G. Caley, botanist, in 1804. Named by him "Ferntree Hill." Re-named "Tomah" (an aboriginal name of unknown meaning) by Surveyor-General Mitchell in 1834.

Topographically surveyed by W. R. Govett in 1832. Previously visited by Alan Cunningham in 1823[1]; Mitchell in 1827[2]; Strzelecki in 1839[3]; and Dr. Woolls in 1861.[4]

As in the case of Mount Wilson, at a later date, the flora of Tomah claimed most attention. Caley and Govett overlooked the cause of its luxuriance—more remarkable, perhaps, in the case of Govett, after his long and arduous experience of the rugged plateau sandstone and its lack of sustenance for his pack animals.

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[1] Hooker's Journ. of Botany, iv, 1842, p. 286.

[2] Three Expeditions, 1838, p. 151.

[3] Phys. Description of N. S. Wales and Van Dieman's Land, 1845, p. 58.

[4] Contributions to Flora of Australia, 1867, pp. 173 181.

Mitchell was probably the first to note the difference recording "trap" and "grey porphyry." Strzelecki, after first ascending Mount Hay, found his way round the head of the Grose to Mount Banks or King George and Tomah, and rightly described the summit rocks as basalt. Cunningham, the botanist, noted the "fat argillaceous loam" and the large blocks of compact "whinstone."

Dr. Woolls, in addition, recorded the presence of Wianamatta Shales under the basalt, having a thickness estimated at from one hundred to one hundred and fifty feet by Professor T. W. E. David.[1]

At the Trigonometrical station the Writer measured two hundred and sixty-five feet of basalt above the shales, which has been determined by Mr. G. W. Card as doleritic olivine basalt [5277].

Bell's Line, an early stock route over the Blue Mountains, crosses Tomah, and skirts the northern shoulder of Mount Bell, which is connected with the former by a very narrow natural bridge between the waters of the Grose and Colo. On the western fall of Tomah into the valley, between it and Bell, the basalt is exposed in the old road cutting resting on clay shales three hundred and forty-five feet below the Trigonometrical station. Columnar structure is here pronounced.

Towards Bell, and at the northern end, the basalt occurs as a superficial flow. South and south-easterly jungle vegetation is so dense, and the soil and vegetable débris so obscuring, that contacts are hidden. Whether a vent occurs at Tomah has yet to be demonstrated. So far as investigation at present is possible no indications are observable.

The basalt area at Tomah is about six hundred acres, but, like all such occurrences, the rich resultant soil gravitates some distance below the actual basalt boundary, where slopes are favourable and sudden sandstone escarpments do not intervene.

[5277] **Olivine-Basalt** (doleritic).—A black aphanitic rock, with abundance of olivine. Under the microscope it is seen to be considerably coarser than the other basalts hitherto examined from the Blue Mountains. Numerous phenocrysts of fresh olivine, augite, and plagioclase are embedded in a holocrystalline fluidal groundmass of felspar, augite, and magnetite.

Olivine is fresh, save for incipient serpentinization along cracks. It is sometimes automorphic.

The phenocrysts of felspar are tabular, and may attain considerable dimensions. They are quite fresh, but are often crowded with foreign particles, among which augite is conspicuous. The extinction angle is high, and indicates a species of labradorite.

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[1] Journ. R. Soc. N. S. Wales, 1902, xxxvi, p. 367.

The groundmass consists of microliths of plagioclase with a somewhat fluidal disposition, entangled with magnetite, augite, olivine, and nepheline.

The chemical composition is as follows :—

	Weight percentage.	Molecular ratio.
SiO_2	46·42	·774
Al_2O_3	17·42	·170
Fe_2O_3	3·70	·023
FeO	7·45	·104
MgO	6·61	·165
CaO	8·56	·153
Na_2O	3 61	·058
K_2O	1·80	·019
H_2O (100° C)	0·34	...
H_2O (100° C+)	1·52	...
CO_2	0·04	...
TiO_2	1·88	·024
ZrO_2	none.	...
P_2O_5	0·87	·006
SO_3	none.	...
Cl	0·05	...
F	(?)	...
S (FeS_2)	none.	...
Cr_2O_3	0·006	...
NiO, CoO	0·02	...
MnO	0·02	...
BaO	0·03	...
SrO	trace.	...
Li_2O	none.	...
V_2O_5	0·01	...
	100·35	
O = Cl	0·01	
	100·34	

Analysis of Mount Tomah Basalt by J. C. H. Mingaye.

Specific gravity, 2·905.

From this analysis, the molecular constitution can be calculated as follows :—

Orthoclase	10·5
Albite	24·1
Anorthite	25·9
Nepheline	3·4
Diopside	9·5
Olivine	14·2
Magnetite	5·3
Ilmenite	3·6
Apatite	1·9

By the Quantitative System, it would be classed as II, 5, 3, 4, under the name of **Andose.**

The unexceptionally low percentage of Mn O is noteworthy. Although nepheline has not as yet been detected microscopically, it must be present, since there is insufficient silica to combine with the whole of the soda in the proportions necessary to produce albite. The amount of manganese present is exceptionally low for an igneous rock.

Mount Tootie, Sheet 12, Parish Bowen, County Cook, on the Bloomsbury Park Estate. Trigonometrical sub-station. Approximate height, two thousand six hundred and twenty feet above sea-level. Thickness of olivine-

basalt cover about one hundred feet. Apparently, two or three hundred feet of Wianamatta Shales intervene between the basalt and Hawkesbury Sandstone, thus augmenting area of productive land.

Basalt covers the remnant of an early drainage channel, filled with large, well-worn boulders and pebbles of Devonian quartzite, from which springs issue on east side. Area of basalt, about forty-five acres.

About half a mile north, a smaller mass of similar composition—" Little Tootie "—reaches an approximate height of two thousand six hundred feet. Area, about twenty acres.

[5293] **Olivine-Basalt.**—An aphanitic, blackish-grey rock. It is conspicuously amygdaloidal, the larger vesicles remaining unfilled, being lined only with an opaque white structureless zeolitic material.

Under the microscope it is holo-crystaline. The occurrence of small phenocrysts of olivine occasions an inconspicuous micro-porphyritic texture. The mineral components are olivine, plagioclase, felspar, augite, and magnetite; both augite and olivine are xenomorphic. Areas occupied by included material that has been re-crystallized are present. Serpentinization is incipient only. Felspar occurs abundantly as laths forming a meshwork; fluxion is hardly noticeable. Magnetite is abundant in evenly distributed little crystals.

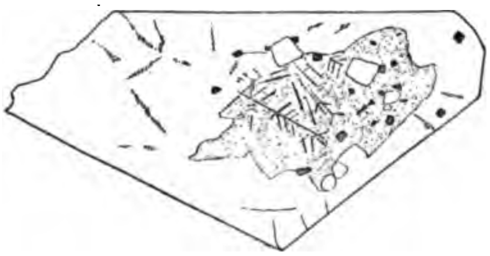
[5295] (Little Tootie).—This rock is practically identical with that from Tootie. Some phenocrysts of olivine are present.

Mount Touwouwan, Sheet 14, Parish Never Never, County Phillip. Elevation, about three thousand five hundred and sixty-five feet above sea-level. A long narrow mountain, probably a neck. Sandstone level, about three hundred feet below summit. Steep talus of basalt on north-west. Area of basalt, about one hundred and twenty acres.

[5854] **Olivine-Basalt.**—A black rock, breaking with a sub-conchoidal fracture, and thickly studded with olivine, which sometimes forms large masses. Augite can be picked out on weathered surfaces.

Under the microscope abundant phenocrysts of olivine and augite lie in a holo-crytalline, granular groundmass of augite, with some felspar and magnetite. The olivine is fresh; its phenocrysts may be automorphic, but are commonly irregular and corroded. The phenocrysts of augite are in large proportion automorphic; they display strong pleochroism, and are often distinctly zoned. One crystal shows an internal bleaching, accompanied by the separation of rutile. Rods of this rutile form the so-called "sagenite-web," lying, approximately, at an angle of 120 degrees to one another. With ordinary magnification, the rods appear black, but with higher powers translucency, with strong pleochroism in shades of brown, can be made out. The neighbouring material is stained brown, and is also pleochroic. The augite phenocrysts contain numerous glass inclusions. Felspar occurs only in the groundmass, and forms tiny rods showing albite-lamellation.

FIG. 13.



Rutile in Augite.

Mount Uraterer Neck, Sheet 14, Portion 1, Parish Innes, County Hunter. Trigonometrical sub-station; height, about two thousand eight hundred and twenty-five feet above sea-level.

A prominent basalt mountain, commanding an extensive prospect, and embracing about three hundred and seventy acres of rich grazing and agricultural land. Taken up by R. Gosper, in 1877, and continuously occupied for over ten years. Used as a cattle run, but corn, oats, potatoes, pumpkins, &c., raised for home use.

Approachable by bridle-track from Long Wheeny, or along range from Main Dividing Range, at head of Cudgegong River. Dominates the Hawkesbury Sandstone plateau by about three hundred and fifty feet.

[5539] **Olivine-Basalt.**—Blackish grey in colour; fracture hackly. Olivine may sometimes be seen in coarse lumps, but the rock is otherwise aphanitic, the crystalline character being just distinguishable with a lens. White amygdales occur here and there.

Under the microscope the texture is micro-porphyritic, with phenocrysts of fresh olivine in a distinctly holo-crystalline groundmass; the thin section shows one corroded phenocryst of purple augite; the felspar microlites immediately adjacent to this crystal are perfectly oriented parallel to its margin; olivine is fresh, and the crystals are corroded; the groundmass consists of augite, plagioclase, and magnetite.

[5540] **Olivine-Basalt** (analcite-bearing). From top of mountain.—A dark grey rock, breaking with a most irregular, lumpy fracture.

Under the microscope it is distinctly holo-crystalline, and not porphyritic; olivine is in part deep red in colour; the general groundmass consists of augite, plagioclase, olivine, iron ores, and isotropic material, regarded as analcite.

Mount Wareng Neck, east of Sheet 14, Parish Burton, County Northumberland. Height, one thousand nine hundred and thirty-four feet above sea-level. Mounts Yengo, Wareng, and Poppong occur almost in a meridianal line, the distances between being about eight and eight and a half miles. The two former occur well within the watershed of the Macdonald River, and are rendered very conspicuous from great distances bv the extent of surrounding denudation.

Wareng lies about two miles south-south-east of Howe's Valley, and the Macdonald River sweeps round its northern and western foot. It forms a high cone rising about four hundred and fifty feet above the Hawkesbury Sandstone rim, which falls steeply away for the most part of the circumference.

Denudation has so isolated both Wareng and Yengo that little or no evidence of their eruptive character is visible. The coarsely-crystalline nature of the Wareng rock (resembling that of Warrawolong) indicates a slowly-cooled central plug.

In some parts of the circumference, a narrow platform of sandstone occurs beyond the basalt; in others, the edge of the former only is visible; the fall, therefrom, being steep. If peripheral tuffs and agglomerates existed on the rim rock, no trace is now visible.

A highly porcellanised fragment of Coal Measure Shales, however, was found at the neck rim, having been ejected or carried up from the underlying beds.

Possibly Wareng may represent a lava cone formed over the orifice. Area of basalt, about two hundred and fifteen acres.

Composition: ophitic (olivine-bearing) dolerite [**5555**].

Base of basalt talus (?) on north and south-west sides, one thousand three hundred and thirty-five feet and one thousand three hundred feet.

PLATE XII.

J. E. Carne.

MOUNT WARENG FROM HOWE'S VALLEY.

Mount Wilson, Sheet 12, Parish Irvine, County Cook. Probably named after the Honorable Bowie Wilson, Minister for Lands, in 1869, when first areas were measured for sale, and a road of access cut, *viâ* Bell. In 1895 allotments, aggregating one thousand and twenty-five acres, were sold, and first residences erected.

The western portion of Mount Wilson Range was traversed by Surveyor Govett in 1832, who noted on his plan the richness of the soil, and alluded to its sudden rise " like ' Tomah,' " and its clothing of similar "peculiar vegetation," but failed to note the change in rock formation.

Mr. George Card, A.R.S.M., has been good enough to examine a micro-section of the rock, and gives me the following description of it:—"The rock is an olivine-basalt. The minerals present are olivine, augite, plagioclase felspar (probably labradorite), magnetic (and other) iron oxides. These are embedded in a light-brown glass. The felspar microlites give rise, by their disposition, to a good fluidal structure, floating round the porphyritic constituent. Olivine is abundant and remarkably fresh. It occurs as porphyritic individuals, presumably from an earlier stage of crystallisation, and numerous granules, through the rock. The augite has a tendency to assume a purplish tint, and is slightly pleochroic."

Later investigation discredits the dyke origin. It seems more probable that the drop in the basalt level, at Waterfall Creek, marks the western fall of a pre-basaltic Bowen Valley, between Wilson and Tomah, the lower levels of which are attested by the olivine-basalt remnants capping the Haystack, and other intermediate cones, which denudation spared whilst sculpturing the present topographic features. All indications point to flow-structure over the site of Mount Wilson and the continuity of the basalt over Mount Hay, Mount Banks, or King George, Tomah, Irvine, and Tootie. The two last-mentioned of which afford conclusive proof of superficial lava flow.

Olivine-basalt [**3345** and **5291**].—[**5291**], from "The Waterfall," is jointed and somewhat platy. Olivine phenocrysts are abundant and conspicuous, sometimes occurring in large masses. Some augite and felspar are also visible.

Under the microscope these minerals, together with magnetite, lie in a fluidal groundmass of microlitic felspar and augite. The olivine is perfectly fresh; it is at times automorphic. All the phenocrysts are much corroded; in the case of felspar, the crystals may be largely occupied by a network of glassy and stony matter. Some of the felspar phenocrysts show a zone of inclusions parallel to the corroded contour. Augite occurs principally as a groundmass mineral. Augite phenocrysts are deeply embayed by the groundmass, and are sometimes copiously traversed by it in network fashion.

A slide from another specimen [**3345**, exact locality unknown] shows some brown glass, and a few zeolites. A large grain of diopside, of foreign origin, is also present.

Mount Wilworril, Sheet 14, Parish Kelgoola, County Phillip. On Main Dividing Range, separating east and west waters. Elevation of cone, about three thousand nine hundred and sixty-eight feet above sea-level. Dominates sandstone plateau level, rising about three hundred feet above highest exposure. Area of basalt, fifty-six acres.

[**5868**] **Olivine-Basalt.**—Greyish-black in colour, jointed, and breaking with a sub-even fracture. Reddish olivine is plentiful, and at times conspicuous.

Under the microscope the texture is doleritic and micro-porphyritic. Olivine is abundant, showing a marginal red weathering zone; its phenocrysts are occasionally automorphic. The groundmass consists of augite, felspar, olivine, and magnetite. The felspar is in small microlites only.

side to a depth of one hundred and ninety feet below summit. The latter rises a few feet above sandstone on opposite side. Area about one and a half acres.

[5824] **Olivine-Basalt.**—Colour greyish black; fracture uneven to hackly. Olivine is plentiful.

Under the microscope the texture is almost doleritic. Olivine is at times automorphic, and is but slightly altered. The groundmass consists of augite, plagioclase, and magnetite, with a dusky, purple and brown-coloured, isotropic base. The groundmass felspar may become subphenocrystalline.

Native Dog Hill Neck, Sheet 14, Parish Kelgoola, County Phillip. Elevation about three thousand and ninety feet above sea-level. Top of sandstone rim about two thousand nine hundred and ninety feet. Area about ten acres.

[5871] **Olivine-Basalt.**—A black rock breaking with an uneven to hackly fracture. Olivine and augite are visible, the former sometimes in conspicuous masses. The hand specimen also shows an inclusion of felspar-augite rock of the size of a Spanish nut.

Under the microscope the groundmass is fine-grained, and consists of tiny microlites of plagioclase, with augite and magnetite. Fluxion is indicated by the plagioclase microlites, but is not strongly marked. The olivine is fresh, save for some weathering stains and slight serpentinization.

New Found Out Clear, Sheet 14, Parish Gullongulong, County Hunter. Elevation one thousand and seventy-five feet above sea-level. Circular-open forest; well-grassed; in sandstone country; composition obscured.

Nullo Mountain, sheet 14, Parishes Pomany, Never Never, Nullo, and Simpson, County Phillip. Lava sheet forming broad plateau. Largest undenuded basalt area within the three sheets accompanying this Memoir. Height about three thousand six hundred and fifty to three thousand eight hundred and fifty feet above sea-level. On east and south terminates abruptly in wall-like embankment of talus slope, at Wallaby Rocks and Racecourse Point, overlooking Widdin Brook.

Area about five thousand eight hundred acres of rich soil, partly covered by forest reservation, though useful timber is confined to very limited area. Very suitable for settlement.

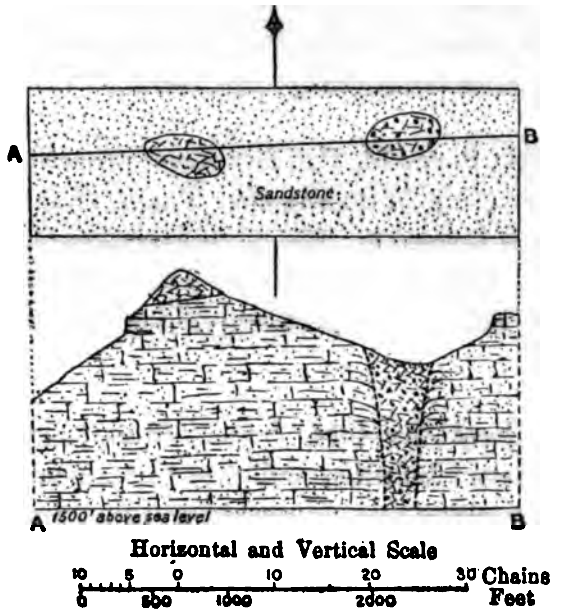
[5888] **Olivine-Dolerite** (Nepheline-bearing).—Greenish-black in colour, jointed, and breaking with an even fracture. The doleritic texture is well shown on weathered surfaces, on which the augite stands out in black masses.

Under the microscope the preponderance in size of the augite over the other constituents gives rise to a porphyritic texture. Here and there augite encloses felspar ophitically, but very rarely. Olivine is always partially serpentinized. The plagioclase shows combined Carlsbad and

Under the microscope it is micro-porphyritic, with slightly serpentinized olivine. The groundmass is black through abundance of pigmental magnetite. It contains plagioclase as tiny microlites, and augite in very small granules.

[5548] Volcanic Agglomerate.—A yellowish-green, highly altered rock, with much calcite and some secondary quartz.

FIG. 14.—PUTTY Hill Volcanic Neck and Flow.



Red Forest Flow, Sheet 14, south of Portion 4, Parish Kelgoola, County Phillip. Elevation about two thousand five hundred and thirty-eight feet above sea-level. Near junction of Saw-mill Creek and Cudgegong River. Area about seven acres.

Red Range Dyke, Sheet 14, Parish Kelgoola, County Phillip. Elevation about two thousand eight hundred and fifty-eight feet above sea-level. An irregular-shaped dyke mass, probably connected with closely adjacent necks. At highest point, intruded plateau sandstones highly vitrified and almost vertically inclined. Strike curving across Cudgegong River.

[5870] Olivine-Basalt.—A slightly amygdaloidal jointed rock, greyish black in colour, breaking with a sub-even fracture. The texture is almost doleritic. Some olivine is present.

Under the microscope there is abundant phenocrystalline olivine and plagioclase. The groundmass is almost interstitial; it consists principally of augite, with some felspar and isotropic material. Magnetite occurs as scattered masses. A few small spherical amygdales are present.

Round-topped Arm Neck, east of Sheet 14, Boggy Swamp, Portion 12, Parish Putty, County Hunter. Elevation, about seven hundred feet above sea-level. In Hawkesbury Sandstone. Filling, principally tuffs and agglomerates; with included water-worn pebbles of intruded strata, probably from Upper Marine conglomerates. Basalt exposed in small knoll.

This "clear" forms a basin dominated by sandstone cliffs. Surface richly soiled and well-grassed. Tuffaceous filling exposed in drainage channel. Area, about twenty acres.

[5821] **Olivine-Basalt** (nepheline- and analcite-bearing).—Colour black, fracture hackly. Olivine is abundant and conspicuous.

Under the microscope the olivine phenocrysts are irregular for the most part, seldom showing crystal faces. The mineral has undergone some alteration. The groundmass is distinctly crystalline and almost monchiquitic. It consists of augite, felspar, nepheline, analcite, and magnetite. Augite is purple in colour; it is not markedly automorphic. It is difficult to discriminate accurately between plagioclase, nepheline, and analcite. From a comparison of refractive indices it is tolerably certain that analcite is present as well as the other two. The radiating fibres which are frequently seen traversing the analcitic component present in so many of the Post-Triassic basalts are visible.

	Weight percentage.	Molecular ratio.
SiO_2	43·32	·722
Al_2O_3	14·97	·147
Fe_2O_3...	3·50	·022
FeO	7·11	·099
MgO	10·51	·263
CaO	9·78	·175
Na_2O...	3·33	·053
K_2O	0 78	·009
H_2O (100° C)	0·44	...
H_2O (100° C+)	3·94	...
CO_2	0·11	...
TiO_2	1·80	·023
ZrO_2	none.	...
P_2O_5	0 48	·004
SO_3	none.	...
Cl	trace.	...
S (FeS_2)	none.	...
Cr_2O_3...	0 02	...
NiO, CoO	0·05	...
CuO	trace.	...
MnO	0·06	...
BaO	0·06	...
SrO	trace.	...
Li_2O	trace.	...
V_2O_5...	0·02	...
	100·28	
Specific Gravity	2·956	

Analysis of Monchiquite [5821] from Putty, by J. C. H. Mingaye.

The norm, calculated from this analysis, is as follows:—

Orthoclase	5·0
Albite	17·8
Anorthite	23·6
Nepheline	5·4
Diopside	14·6
Olivine	19 0
Magnetite	5·1
Ilmenite	3·5
Apatite...	1·3

By the Quantitative System it would be classified as III, 5, 3, 4, under the name of **Camptonose.**

Boiling in dilute (1 : 40) nitric for two minutes, a large portion of the rock is soluble. The composition of this soluble portion is as follows :—

	Weight percentage.	Molecular ratio.
SiO_2	13·30	·272
SiO_2 soluble in caustic soda... ...	3·33	
Al_2O_3...	7·81	·076
Fe_2O_3...	1·90	·012
MgO	2·87	·072
CaO	1·44	·025
Na_2O...	3·29	·053
K_2O	0·36	·004
H_2O	2·48	·139
CO_2	0·11	...
P_2O_5	0·39	·003
	37·28	

From these figures the approximate composition of the soluble portion can be calculated as follows :—

Analcite	23·3
Olivine	6·2
Calcite	1·1
Apatite...	1·0
Potassium silicate	A small quantity of these remains unaccounted for.
Alumina ...	
Lime	

The amount of silica present is just sufficient to form analcite with the soda, but is in far too great quantity for nepheline. Alumina is the cause of some uncertainty, however, as considerably more has gone into solution than is required to satisfy the alkalies. The Clark-Steiger test for the determination of analcite yielded rather lower results. It seems certain that about 20 per cent. by weight of this rock has the composition of analcite.

St. Helena Neck, a little south of Sheet 12, Parish Magdala, County Cook, some six miles south-westerly from Glenbrook. Elevation about six hundred and fifteen feet above sea-level. A semi-circular basin of an area of about thirty acres, lying about three hundred and twenty-five feet below the surrounding plateau sandstone level. Filling largely tuffaceous. Olivine basalt at lowest point exposed by drainage channel which has sawn through the sandstone rim and removed the neck filling to a depth of over three hundred feet,

one hundred and seventy-five feet below summit of neck. Tuffs and iron ore are associated on eastern rim, which is highly vitreous. Area, about nine and a half acres.

[5937] Glassy Olivine-Basalt.—Colour black, fracture hackly. The groundmass is markedly aphanitic, and is porphyritic with much inconspicuous olivine.

Under the microscope, olivine and a little augite occur as phenocrysts, the former being perfectly fresh. The base is isotropic, brown in colour, and occupies a considerable proportion of the slide; it must be regarded as glass. Imbedded in this glass—in addition to the phenocrysts—is an abundance of microlitic felspar, granular augite, and magnetite. In the glass lie a great number of straight black rods, which show some tendency to symmetrical disposition; these do not seem to be crystallites, and their nature is uncertain.

Spring Hill Forest Neck, Sheet 14, Portion $9\frac{3}{18}$, Parish Never Never, County Phillip. Height above sea-level, about two thousand four hundred and sixty-eight feet. Area about fifteen acres. Composition not disclosed. Open forestry and grass-land.

Swampy Arm Neck, Sheet 14, Portion 28, Parish Tupa, County Hunter. Elevation, about one thousand and forty feet above sea-level. Rim rock, Hawkesbury Sandstones and conglomerate; showing inward dip of thirty to forty degrees. Filling, tuffaceous. Basalt scarce. Area about fifteen acres.

[5820] Olivine-Basalt.—Colour greyish-black, fracture uneven to hackly. Olivine can be seen, but is not conspicuous.

Under the microscope, olivine appears as somewhat serpentinized masses, which are much corroded. A large mass of plagioclase is included, which shows much marginal absorption and alteration; one effect of the alteration has been the separation of iron as dark red lines of ferric oxide. Associated with this felspar is a piece of augite. The groundmass is fine-grained, consisting of augite, magnetite, microlitic felspar, and clear isotropic material.

Swampy Hole Neck, Sheet 14, Parish Coricudgy, County Hunter. Elevation of highest point, two thousand seven hundred and fifteen feet above sea-level; lowest, two thousand five hundred feet.

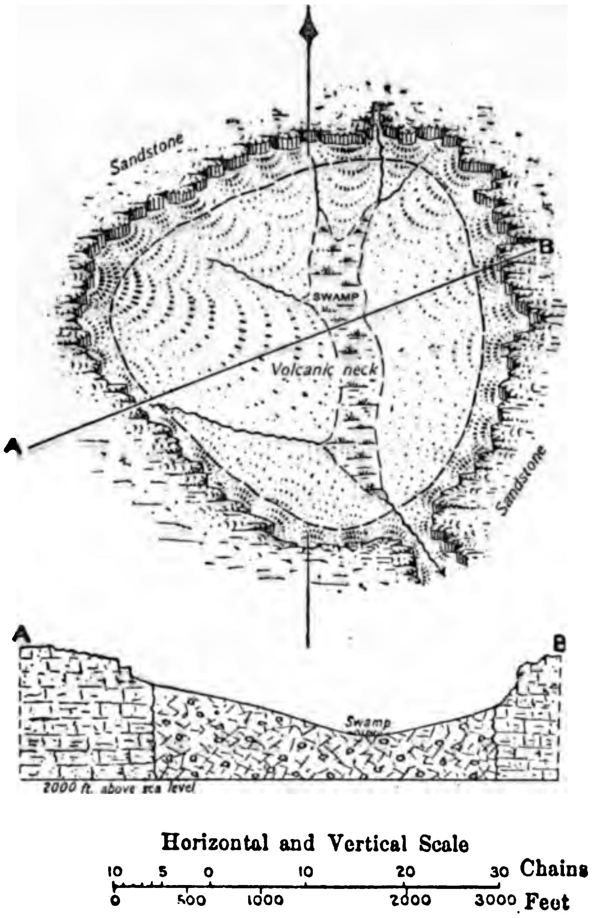
A remarkable neck surrounded by vertical cliffs of plateau sandstone from one hundred and seventy to three hundred and eighty feet in height, the circular wall being broken only by narrow cleft of drainage channel.

Filling apparently entirely tuffaceous. Area about one hundred and thirty acres of rich open forest land, well-grassed. Used for grazing purposes in bad seasons. Approach being possible by narrow bridle-track down Wirraba Creek from Dividing Range, between it and Right Nile Creek.

[5865] Tuff.—A calcareous, greenish-yellow rock, in which quartz and fragments of basalt can be seen.

Sweet Ridge Neck, Sheet 14, Parish Kelgoola, County Phillip. Small circular patch of open forest—probable neck.

Fig. 15.—Swampy Hole Volcanic Neck.



Tambo Limb, Sheet 12, Parish Govett South, County Cook. Conspicuous conical peak about two miles easterly from Mount Cameron. Height, about three thousand five hundred and twenty feet above sea-level. Thin capping of olivine-basalt (about fifty feet). Area, about five acres.

[6218] **Olivine-Basalt.**—An olivine-bearing, blackish-gray rock, with a platy structure.

Under the microscope it is micro-porphyritic, with olivine phenocrysts which have undergone considerable serpentinization. They are now and then automorphic. The groundmass is sub-fluidal, with abundant felspar laths ; augite, magnetite, and an occasional nest of chlorite are also present.

Table-top Yellow Box Forest Neck, Sheet 14, Parish Ganguddy, County Roxburgh, about one mile south-south-easterly from White Gum Forest. Elevation, about two thousand four hundred and seventy-three feet above sea-level. Area, about two acres. Sandstone rim nearly level with basalt pipe, except at bluffs twenty feet high; rim sandstone altered; tuffs visible.

Tayan Pic, Sheet 14, Parishes Umbiella and Tayar, County Roxburgh. Trigonometrical sub-station. Approximate height, about three thousand eight hundred and sixty feet above sea-level.

A most symmetrical cone, dominating the Hawkesbury Sandstone by about six hundred feet, and the crater on its northern base by about nine hundred and seventy feet. Apex very small, southern angle of dip approaching forty-two degrees; upper portion a talus or jumble of columnar blocks.

A tributary head of Bogie Nile Creek drains the lower rim (north) of the crater. Contact rocks are well exposed; sandstone rim hardened, and inclined inwards; peripheral tuffs and agglomerates partake of same inclination, as illustrated in views and sections.

Composition of cone, olivine-basalt [**4543**], approximating to dolerite; agglomerate [**5846**], ferruginous and highly calcareous.

Area of peak and crater, about one hundred and seventy-five acres.

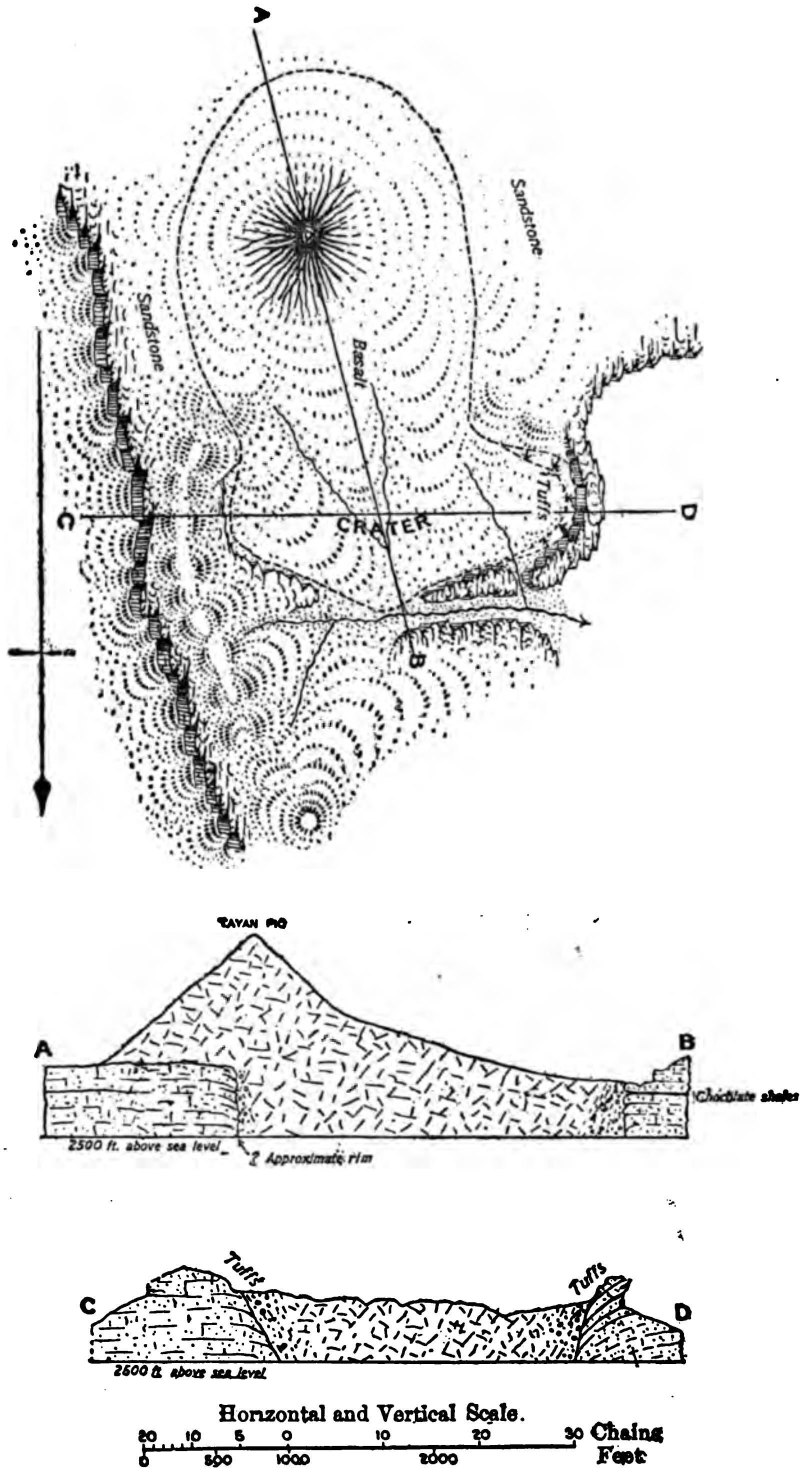
The Haystack, Sheet 12, Parish Irvine, County Cook. Approximate height, about three thousand and seventy-five feet above sea-level. Named by G. Caley, in 1804.

A conspicuous basalt-capped cone within the Bowen Valley, on the east bank of Bowen Creek. Most conspicuous from south-west or north-east. Area of olivine-basalt less than one acre.

Close by, on the south, are two smaller and less prominent remnants of the lava-sheet which once connected Mounts Wilson and Tomah.

Across Bowen Creek, two other small patches of basalt occur, marking, probably, the lowest level of the pre-basaltic valley between the eastern and western ridges beneath Tomah and Wilson coulées.

FIG. 16.—TAYAN PIC Volcanic Neck and Cone.



The Haystack Volcanic Neck, Sheet 13, Parish Clandulla, County Roxburgh. At north end of mountain, half of periphery removed to base level. Sandstone rim baked, quartzitic or vitreous character developed; huge blocks of sandstone engulfed and now exposed on side of crater throat, baked, altered, and partly tuffaceous; around existing portion of summit rim iron ore developed. Filling: olivine-basalt, tuffs, and agglomerates.[1]

Tea-tree Basin Neck, Sheet 14, Parish Pomany, County Phillip, near tree marked $\frac{5}{\text{PH}}$. Elevation, three thousand two hundred and sixty feet above sea-level, approximately. Area, about eight acres. Composition obscured.

"The Ovens" Neck, Sheet 14, Parish Kelgoola, County Phillip. Elevation about two thousand eight hundred and seventy-two feet above sea-level, hollowed out about fifty lower. A typical neck, with dyke extending from it for a short distance. Filling, basalt and tuffs. Area about forty-five acres.

[**5856**] **Olivine-Basalt** (nephelinic).—A greyish-black, jointed rock, breaking with a hackly fracture. Olivine is visible as small masses.

Under the microscope the olivine is fresh but for slight staining, and forms irregular phenocrysts. The groundmass consists of plagioclase, granular augite, nepheline, and some crystalline magnetite. Plagioclase laths are abundant, and show a slight tendency to fluxion.

The Pinnacle Neck, Sheet 14, Parish Pomany, County Phillip. Height about three thousand three hundred and twenty-five feet above sea-level. Summit about ninety feet above sandstone rim on south boundary. Broken down north and east. Area about five acres.

[**5884**] **Olivine-Basalt.**—Black or greenish-black in colour, breaking with uneven and hackly fractures. Olivine is abundant and conspicuous.

Under the microscope the olivine phenocrysts are automorphic, but corroded. The groundmass comprises microlitic augite, felspar, and magnetite, but is difficult to resolve. A fragment of olivine-dolerite is enclosed, and is separated from the groundmass by an irregular, but quite sharp, boundary. There are other areas which appear to be xenoliths that have been almost assimilated, and now merge into the groundmass. A fragment of pleonaste is also enclosed.

Top Forest Neck, Sheet 14, Parish Tayar, County Roxburgh, about three miles north-north-westerly from Tayan Pic. Elevation about two thousand nine hundred and fifty-five feet above sea-level. Area about five acres. Circular form. Open forestry.

Tongbong Mount, Sheet 13, Parishes Louee and Tongbong, County Phillip. Summit formed of olivine-dolerite sill [**6652**] rock intruding Coal Measures. [*See section on Sheet* 13.] Height about two thousand eight

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[1] Mem. Geol. Survey N.S. Wales, Geol. 3, 1903, p. 153.

The norm, calculated from these results, is as follows:—

Orthoclase	3·9
Albite	16·2
Anorthite	14·7
Nepheline	10·5
Diopside	23·9
Olivine	8·8
Magnetite	8·3
Ilmenite	6·2
Apatite	1·7

Regarding analcite as a combination of albite, nepheline, and water in the proportions 1 : 1 : 2 (admitting the small amount of potash present as an ingredient of the felspar molecule), the percentage of analcite present would be 3·3. A small proportion of anorthite will enter into the augite. The approximate mineral composition will then be the following:—

Analcite	33
Augite...	25
Iron ore	15
Anorthite	13
Olivine	9
Apatite	2
Water, &c.	3

Top Paddock Ridge Neck, Sheet 14, Parish Tayar, County Roxburgh. Elevation about two thousand eight hundred and thirty feet above sea-level. Area about eight acres.

Wheelbarrow Mountain, Sheet 13, Parishes Coolcalwin and Growee, County Phillip. Elevation about three thousand four hundred and sixty-five feet above sea-level at highest point. Well-grassed, open forest land. Mode of occurrence not yet ascertained. Area about two hundred and fifty acres.

[5867.] **Olivine-Dolerite.**—Black in colour, with lighter mottling. It is jointed, and breaks with a hackly fracture. Olivine is easily discerned, and the holo-crystalline character is evident to the eye.

Under the microscope the texture is slightly porphyritic on account of an occasional pheno-crystalline development of olivine. The mineral components are tabular, plagioclase, augite, olivine, and magnetite. The extinction angle of the plagioclase indicates that a basic species of labradorite, or possibly anorthite, is present. Olivine is abundant, and fresh. Augite is granular, and brown in colour.

Wolgan Junction Neck, Sheet 14, Parish Wolgan, County Hunter, on Capertee River bank, opposite junction of Wolgan River. Olivine-basalt. Area small.

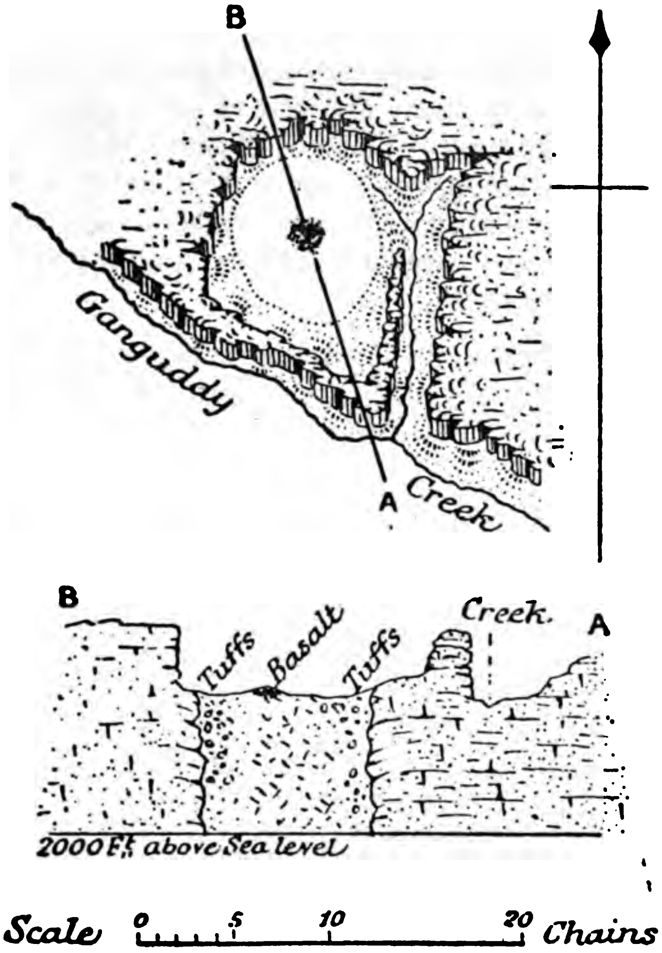
White Gum Forest Neck, Sheet 14, Parish Kelgoola, County Hunter. An interesting example of a small neck surrounded by vertical cliffs of Hawkesbury Sandstone (illustrated in accompanying plan and section). The denuded neck filling but little above the level of Ganguddy Creek. Height

above sea-level about two thousand five hundred feet. Surrounding sandstone cliffs rise from one to two hundred feet higher. Filling: central basalt and peripheral tuffs. Area about six and a half acres.

[5860.] **Olivine-Basalt** (analcitic) —Colour black, fracture lumpy. Small phenocrysts of olivine lie in a compact groundmass. Some small xenoliths are present.

Under the microscope the groundmass is fine-textured, and consists of granular augite, tiny felspar laths, pigmental magnetite, and a colourless isotropic base. Both automorphic and irregular phenocrysts of olivine occur. The olivine is, in general, but slightly altered, but occasional small pseudomorphs of serpentine occur. Highly-altered (completely re-crystallised) fragments of sedimentary rocks are enclosed.

FIG. 17.—WHITE GUM FOREST Volcanic Neck.



Windmill Hill Neck, Sheet 13, Portion 1, Parish Rylstone, County Roxburgh. Height above sea-level about two thousand and eighteen feet. Surface enclosing rocks, Coal Measures, near base. Portions of basal conglomerate—Marangaroo—near by, evidently forced up, and hardened. Area about three and a half acres (?). (Part of boundary obscured.)

Under the microscope the structure is seen to be holocrystalline, but not noticeably porphyritic. The minerals present are felspar, nepheline, ægirine, and sodalite, with, perhaps, other felspathoids. It seems probable that the felspar, which occurs as microlites, is soda orthoclase. The ægirine is not uniformly distributed (except in the selvage rock), but is aggregated into groups, having a sub-radial linear structure. This grouping of the ægirine is the special characteristic of the rock.

Nepheline is very abundant, uniformly distributed in well-developed little crystals.

The rock belongs to the great group of the nepheline-syenites, its structure is that of the tinguaite division of this group, and the arrangement of the ægirine is such as to justify the recognition of a new type, which may be conveniently designated as the BARIGAN TYPE.[1]

Sample No. 4767, from Porcupine Mount, Parish Barigan, County Phillip; No. 4967, from Pinnacles, near Jimmy Jimmy, Parish Hawkins, County Phillip.

Chemical Composition.

	Porcupine Mt. Rock, No. 4767.	Jimmy Jimmy Rock, No. 4967.	
	Assay No. 01-3,361.	Assay No. 02-1,004.	
Silica (SiO_2)	53·62	53·30	J. C. H. Mingaye, Analyst.
Alumina (Al_2O_3)	22·78	22·19	
Ferric oxide (Fe_2O_3)	2 62	3·58	
Ferrous oxide (FeO)	·72	1·55	
Magnesia (MgO)	·42	·24	
Lime (CaO)	·68	1·36	
Soda (Na_2O)	10·40	9·73	
Potash (K_2O)	5·22	5·74	
Water at 100° C.	·22	·38	
Water over 100° C.	2·44	1·38	
Carbon dioxide (CO_2)	·07	·02	
Titanium dioxide (TiO_2)	·08	absent.	
Vanadium pentoxide (V_2O_5)	absent.	absent.	
Zirconium dioxide (ZrO_2)	·20	·11	
Phosphoric anhydride (P_2O_5)	·03	·08	
Sulphur trioxide (SO_3)	·05	·09	
Chlorine (Cl)	·19	·12	
Fluorine (F)	trace.	·02	
Ferric disulphide (FeS_2)	absent.	......	
Chromium sesquioxide (Cr_2O_3)	absent.	absent.	
Nickel protoxide (NiO)	absent.	·04	
Cobalt protoxide (CoO)			
Copper protoxide (CuO)	......	·01	
Manganous oxide (MnO)	·05	·47	
Barium oxide (BaO)	absent.	absent.	
Strontium oxide (SrO)	minute trace.	trace.	
Lithium oxide (Li_2O)	absent.	trace.	
	99·79	100·41	
Less oxygen equivalent for chlorine...	·05	·04	
	99·74	100·37	
Specific gravity	2·577	2·618	

Small nepheline-bearing basalt pipes have already been noted at Sapling Flat and the Nile, Capertee Valley.[2]

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[1] "In view of identically similar rocks having been described from Abyssinia, there will probably be no need to make use of a type name. It is hoped that these rocks will be described in more detail in the near future."—[G.W.C.]

[2] Mem. Geol. Survey N. S. Wales, 1903, Geol. 3, p. 152.

The relative positions of the Northern, Southern, and Western coal-seams are shown in the following sections, illustrating the horizons of the three productive Measures.

Since these were prepared, Mr. L. F. Harper, F.G.S, Geological Surveyor, kindly supplied the following additional section of the Southern Coal Measures, between Para Meadow Railway Station and Mount Pleasant Colliery :—

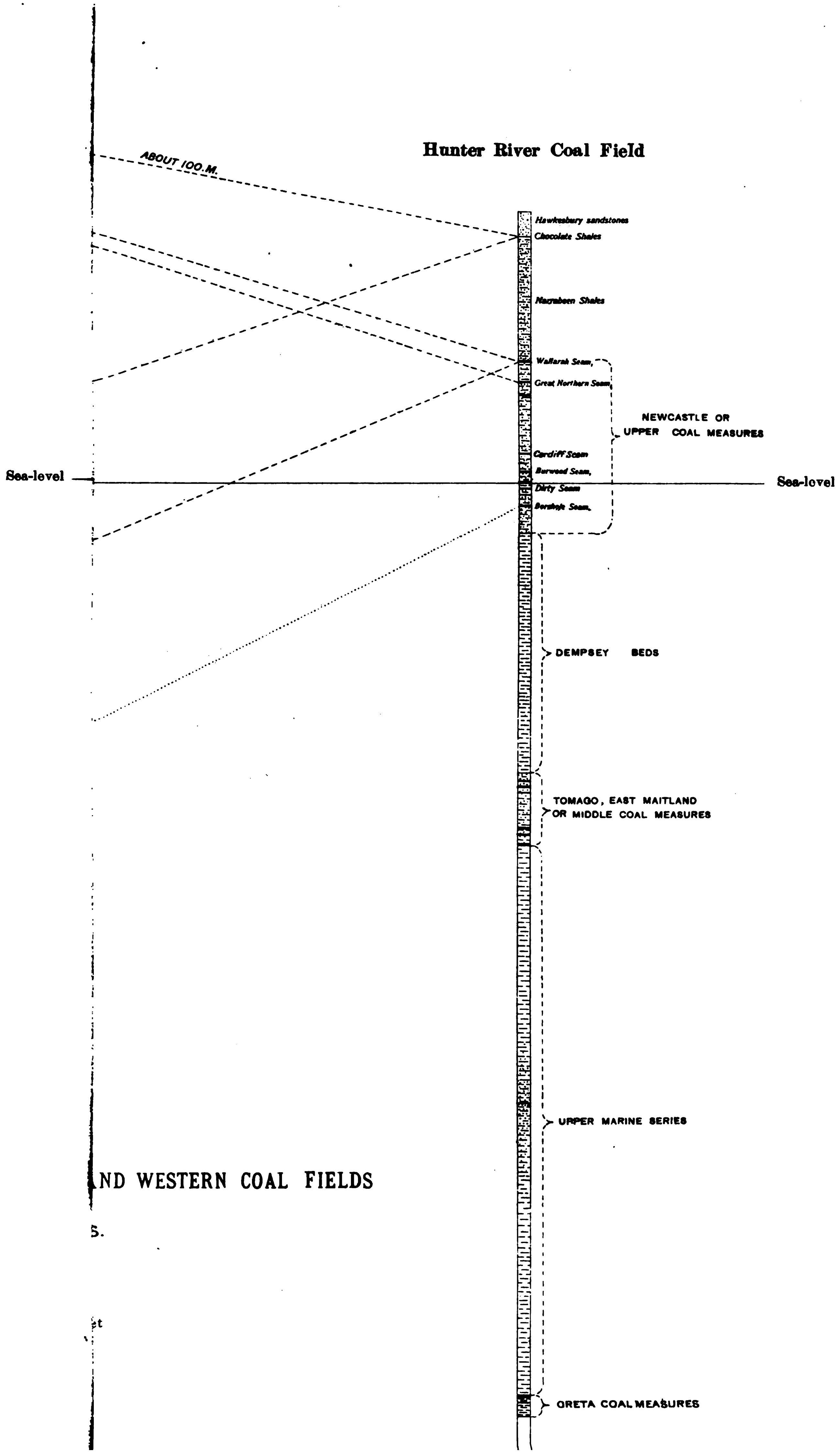
	Height above sea-level.	Seam.
Total thickness, 553 feet.	543 feet	Level of Top, or Bulli Coal seam, Mount Pleasant.
	513 ,,	,, Four-feet Seam.
	475 ,,	,, Dirty Seam (17 feet coal and bands).
	430 ,,	,, 1 ft. 6 in. Inferior Seam.
	350 ,,	,, 4 feet coal and bands.
	300 ,,	,, 4 ft. 6 in. coal and bands.
		An intermediate dirty coal-seam is reported on good authority in this strata ; though no outcrop is visible.
	– 10 ,,	(below sea-level) ; 8 feet coal and bands. Probably Lithgow Seam.

Three of the Western Coal-seams have, so far, been mined where outcrops accessible to railway communication render exploitation profitable—two, however, to a very slight degree only.

The lowest, or "Lithgow," seam, is the principal ; and with two slight exceptions—at Irondale and Hartley Vale—furnishes the present Western output. It is very regular, free from faults, and but slightly disturbed by rolls and "washouts."

In descending order, the first is the "Katoomba," or "Top" seam, immediately at the base of the Hawkesbury Series ; more readily recognisable as the first seam at the foot of the vertical sandstone cliffs forming the upper valley walls. This seam is identical with the "Bulli" of the Southern Coalfield. It has been mined at Hartley Vale, Main Camp, and Katoomba, and slightly prospected on the Grose.

Though locally overshadowed in importance by the thicker "Lithgow" seam, considerable interest attaches to it, because of its correlation with the important "Bulli" seam of the Southern Coal-field, and the Cremorne seam of the Sydney Harbour Collieries. It is, therefore, destined to be the most accessible and chief source of supply in the area between that of the



ND WESTERN COAL FIELDS

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et

Mountain Collieries and the Metropolis; and also between the latter and the shallower workings in the rising northern and southern extensions of the warped Sydney Coal-field.

The great depth—two thousand eight hundred and eighty-four feet—in the Balmain shafts of the Sydney Harbour Collieries to the top of the "Katoomba" seam, and doubtless increased thickness of intercalated strata, will probably preclude any of the lower seams being worked for a long period. The second, or "Dirty," seam of the Blue Mountains, if persistent and of better quality, might be reached at a reasonable depth below the first, though it was untouched at three thousand and seven feet in the Birthday Shaft at Balmain.

The temperature in the first shaft reached one hundred and sixty three degrees,[1] but dropped, after connection was made with the second shaft, to the present temperatures of eighty-three to eighty-six degrees at the working faces over one thousand yards eastward, owing to the improved ventilation.

After proving, by boring, a workable coal-seam at Cremorne, the Sydney Harbour Collieries (Limited) pierced an inferior portion of it at the site of their colliery at Balmain, two hundred and sixty chains south sixty-seven degrees west from No. 2 Cremorne Bore.[2]

In a heading being driven from the Birthday Shaft towards the latter, it is interesting to note the gradual improvement of the seam between the shaft section and the face at one thousand four hundred and eighty-seven yards, both in thickening of the coal and pinching-out of the intercalated carbonaceous shale.

The coal in this seam is of excellent quality as will be seen by the accompanying analyses. The average ash contents of six analyses equal 8·18 per cent. (In one of these the thin band was included.) Of the top coal 8·09, and of the bottom 7·36 per cent. Its steaming properties may be estimated from the relatively high ratio of fixed carbon (71·5 per cent.), and correspondingly high calorific power (nearly 13).

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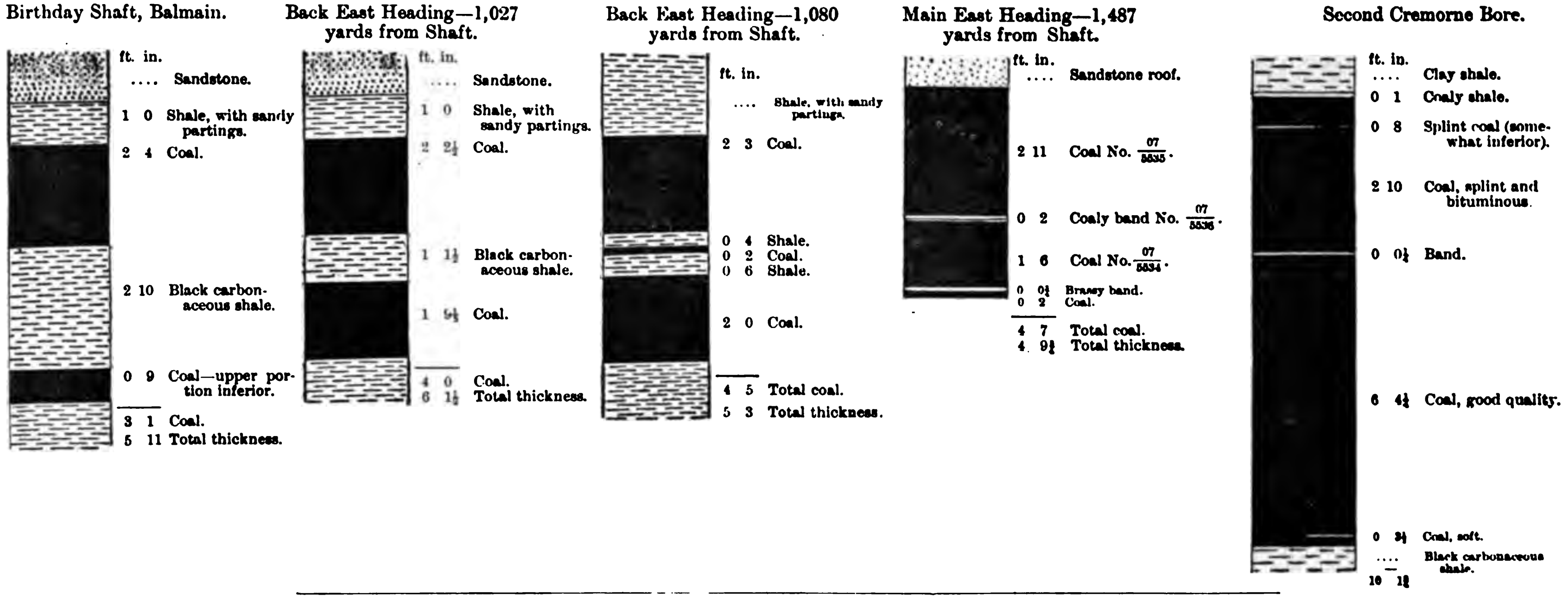
[1] J. L. C. Rae, E. F. Pittman, and T. W. E. David, Proc. Roy. Soc. N. S. Wales, 1899, xxxiii, p. 223.

[2] *Ibid.*, p. 219.

The following sections illustrate the changes in the seam in working in the direction of the ultimate goal at Cremorne, where probably the maximum thickness of the seam was proved:—

FIG. 18.—SECTIONS in heading east towards Cremorne.



Proximate Analysis.	06. No. 6056. Back East Heading 1,080 yds., average.	06. No. 6058. Back East Heading 1,120 yds., Top Coal.	06. No. 6059. Back East Heading 1,120 yds., Middle Coal.	06. No. 6060. Back East Heading 1,120 yds., Bottom Coal.	07. No. 5533. Main East Heading 1,487 yds., average (including bands).	07. No. 5534. Main East Heading 1,487 yds., Bottom Section.	07. No. 5535. Main East Heading 1,487 yds., Top Coal.	07. No. 5536. Main East Back Heading 1,467 yds., Coaly Centre Band.	Second Bore, Cremorne. *	Analyst.
Hygroscopic moisture	·55	·52	·65	·69	0·80	0·75	0·61	1·01	·66	W. A. Greig.
Volatile hydrocarbons	19·17	18·85	18·64	20·93	14·01	20·10	19·71	18·18	17·57	
Fixed carbon	72·01	74·66	66·64	71·66	70·24	71·15	69·46	29·65	71·09	
Ash	8·27	5·97	14·07	6·72	9·95	8·00	10·22	51·16	10·68	
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	
Sulphur in coal	0·384	0·521	0·425	0·480	0·329	......	0·302	......	0·724	
Specific gravity	1·369	1·262	1·419	1·346	1·429	......	1·388	......	1·346	
Calorific power......	12·2	13·2	12·4	13·0	13·5	......	12·9	......	13·00	
Coke	80·28 %	80·63 %	80·71 %	78·38 %	80·19	......	79·68	......	81·77	

* Records Geol. Survey N. S. Wales, 1894-5, IV, p. 7.

Coke ... No. 06-6056—Well swollen, fairly lustrous, brittle.
,, 06-6058—Very much swollen, brittle, dull lustre ...... Ash .. Reddish tinge, flocculent.
,, 06-6059— ,, ,, ,, fairly lustrous .. Grey in colour, semi-granular.
,, 06-6060— ,, ,, ,, dull lustre ...... Reddish tinge, flocculent.
,, 07-5533—Fairly well swollen, firm, dull lustre .... Grey in colour, semi-granular.
, 07-5534—Well swollen, firm, and lustrous .... ,, ,, ,,
07-5535—Fairly swollen, firm, dull lustre .... Light buff colour, semi-granula .

The composition of the intermediate shale band, including the two inches of bright coal which appeared at one thousand and eighty yards from the shaft, is shown in the following analysis :—

No. 6057 (W. A. Greig, Analyst).

Hygroscopic moisture	·79
Volatile hydrocarbons	14·71
Fixed carbon	39·61
Ash	44·89
	100·00

Professor David correlates the Bulli Seam with the Wallarah of the Northern Coal-field, which has a thickness of nine to ten feet, but thins out before reaching Newcastle. The two succeeding seams he also correlates in each district.

Tracing the "Katoomba" Seam to the coast, there is every reason to regard it as identical with the "Bulli" and "Cremorne," which occur in the same relative position, notwithstanding that in the intermediate Moorebank Bore, near Liverpool, two thin seams are recorded above the six feet six and a half inches seam struck at two thousand five hundred and eighty-four feet ten inches, which is correlated with the former.

The first of the thin upper seams (one foot five inches thick) occurs at eighty-seven feet seven inches, and the second (one foot four inches thick) at seventy-six feet above the main seam at Moorebank.

Neither occur at Balmain nor Cremorne, but in the Heathcote and Holt-Sutherland Bores—south of Sydney—the Main Bulli Seam is split. At the former the upper part is four feet eight inches and the lower six feet one inch, separated by sixty-four feet of strata. At the latter the respective thicknesses are four feet two inches and five feet three inches, separated by sixty-six feet of strata.

Westward, at Moorebank, there appears, therefore, to be further splitting of the upper part of the Katoomba Seam.

In the Mountains the roof of the seam is usually sandstone, but carbonaceous shales are sometimes intercalated as at Balmain Shaft.

If, as assumed, the Western Coal Measures correlate with the Southern and with the upper portion of the Northern, there is great improvement—seam for seam—towards the coast, especially towards Newcastle.

In endeavouring to estimate the coal resources of a large and practically unproved area—such as mapped—it would be unwise and against evidence to assume persistent thickness and quality for individual seams.

But with deterioration or diminution in a particular seam or locality, it is not unreasonable to predict compensating improvement in others. Hence an average must be struck between distant points.

Though the top, or "Katoomba," seam outcrops in the Lithgow Valley above the working collieries, its quality, judging from the outcrop at Oakey Park, is not good, and no attempt has been made to open it. For a long period it has been worked at Hartley Vale in connection with the Kerosene Shale retorts and refinery, being opened by tunnels from below the plateau escarpment.

It was first commercially opened at Katoomba, by J. B. North, in 1882, by tunnel and incline; and, in 1885, by the New South Wales Shale and Oil Company, at Main Camp, near Hartley Vale Railway Station, by shaft from the plateau level.

In 1881, short prospecting tunnels were driven in this seam by Mackenzie and Garrett, under the southern cliffs of Grose Valley, in mineral lease 10 and other leases in Parish Blackheath, County Cook, about three miles north-north-west of Mount Victoria Railway Station direct, but nearly twice as far by road.[1]

In 1903 it was tested by a short tunnel in Victoria Falls Creek, about two and a half miles north-easterly from Mount Victoria, by Rienits, Edwards, and others; and in 1905, under the cliffs of Evans' Lookout, on the east side of Beauchamp's Falls, by Kerry and Wall.

Considerable improvement in thickness is noticeable between Hartley Vale and Grose Valley—from two or three feet to five or six.

In the Wolgan and Capertee Valleys, and at the head of Widden Brook—the furthest northern exposure on the accompanying maps—the top seam is valueless, the improvement, as already indicated, being to the north-east, east, and south-east.

The "Lithgow," or lowest seam, on the contrary, *so far* as natural sections and limited provings have laid it open to inspection, deteriorates in these directions, but persists undiminished north-westerly. Unfortunately, in this direction erosion of the extensive Capertee Valley has reduced the productive Measures along the Mudgee railway to a mere fringe between Wallerawang and Rylstone.

The Katoomba Seam has been proved to be from two to six feet thick in the Blue Mountains; six and a half feet at Moorebank, near Liverpool; and a maximum of ten feet at Bulli, Cremorne, and Wallarah, on the coast, where the thickness, as in other localities, is variable. The poor results obtained in the Woodford Bores and Balmain coal-shafts are, doubtless, local.

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[1] On pages 173-174 recent developments on the opposite side of the valley are recorded.

Intermediate boring at Euroka and Breakfast Creek, near Penrith, ceased at a depth too shallow by several hundred feet to reach the top seam, which is here depressed beyond the ordinary dip by the Glenbrook monocline.

[illegible]

[2] *Ibid.*

But with deterioration or diminution in a particular seam or locality, it is not unreasonable to predict compensating improvement in others. Hence an average must be struck between distant points.

Nattai River.

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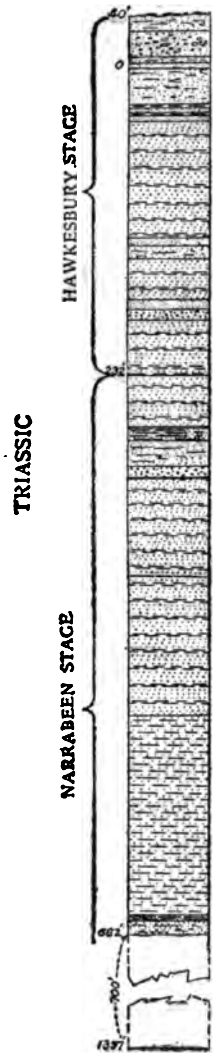
doubtless, local.

On pages 173–174 recent developments on the opposite side of the valley are recorded.

Intermediate boring at Euroka and Breakfast Creek, near Penrith, ceased at a depth too shallow by several hundred feet to reach the top seam, which is here depressed beyond the ordinary dip by the Glenbrook monocline. Southerly from Penrith, it has an exposed thickness of five feet ten inches[1] in the face of the Burragorang Mountain, about one thousand and twenty-five feet above sea-level, three hundred and seventy-five feet below the Chocolate Shales, and nine hundred and twenty-five feet below the summit.[2]

FIG. 19.—SECTION at Euroka and Penrith Bores. (Ann. Repts. Dept. of Mines for 1884 and 1885.)

Scale, 50 feet to an inch.



ft	in.	
12	0	Sandstone.
20	0	Sandstone and conglomerate.
4	0	Sandstone.
31	6	Sandstone.
2	0	Dark shale.
3	3	Sandstone.
2	0	Dark shale.
4	9	Fine sandstone.
98	6	Sandstone, with shale bands.
6	0	Fine sandstone.
10	0	Sandstone.
31	0	Sandstone, with shale bands.
8	0	Fine sandstone.
8	0	Coarse sandstone.
41	6	Sandstone, with shale bands.
		Horizon of grey and purple shales in Penrith Bore. Probably identical with 149 ft. 10 in. level in No. 2 Woodford Bore.
39	9	Sandstones, with shale bands.
1	3	Sandstone and shale.
9	6	Dark shale and sandstone.
20	0	Sandstone.
9	6	Coarse sandstone.
0	6	Shale.
		Bottom of Penrith Bore, 481 feet 3 inches.
182	0	Sandstones, with shale bands.
152	6	Sandstones and shales.
4	0	Sandstone with coal pipe.
10	7	Sandstone.
		Bottom of Euroka Drill Bore, 702 feet 1 inch.
		Probable depth of coal without allowance for thickening of Measures between No. 2 Woodford Bore and Euroka Bore.

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[1] E. F. Pittman, Ann. Rept. Dept. Mines N. S. Wales for 1893, p. 105.

[2] *Ibid.*

A sample of the seam at Burragorang Mountain, properly selected by J. B. Jaquet, in 1903 (about the time of a project for opening it), yielded the following results from about six feet of coal, which are remarkably good, notwithstanding it was taken from the outcrop, the opening extending not more than six feet into the seam :—

Hygroscopic moisture	2·40
Volatile hydrocarbons	26·97
Fixed carbon	58·74
Ash	11·89
	100·00

This seam is followed outside the areas forming the subject of this Memoir, for the purpose of demonstrating its proved extension and thickness as guides to probable value where intermediate proof is wanting.

The difficulty of definitely determining quality, or even thickness in some cases, from natural outcrops, is intensified by the susceptibility of coal to weathering influences. A notable instance is afforded by the important Greta Seam of the Lower Coal Measures. Here a solid coal-seam of thirty feet or more is represented in the outcrop by a thin streak of black dirt (or rotted coal) a few inches in thickness.

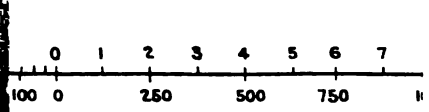
The angle of dip and nature of roof are frequently factors in preservation. The flatter the dip and harder the covering, the firmer the coal outcrop. Still, in rare instances only can quality be gauged in natural outcrops.

The top seam, with its massive cover of plateau (Hawkesbury Series) sandstones, affords the best preserved outcrops; the lowest, or Lithgow, with its sandstone (and sometimes conglomeratic roof) also preserves its thickness at the outcrop. The intermediate seams, however, in friable shales, outcrop as " black dirt."

The stratigraphical position of the Katoomba Seam is shown between Lithgow and Sydney by natural and artificial sections, obtained in Lithgow and Grose Valleys, and in Clarence, Woodford, Euroka, Moorebank, and Cremorne Bores, and the Balmain Birthday Shaft.

SECTIONS BETWEEN LITHGO

STRATA AS SHOWN BY CL

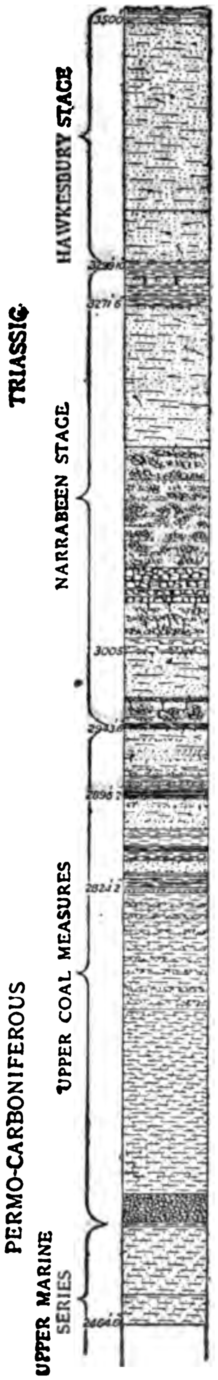


ails of these sections see letter-

DIAMOND DRILL BORES.

FIG. 20—SECTION of Diamond Drill Bore, about one mile east of Clarence, at head of Dargan's Creek. (From Ann. Repts. Dept. of Mines, 1885–1887.)

Scale, 50 feet to an inch.



ft.	in.	
11	0	Surface soil.
144	2	Sandstone.
40	0	Sandstone.
		…… Chocolate shales.—J.E.C.
108	6	Sandstone.
25	0	Sandstone and conglomerate.
68	0	Sandstone, chert, and conglomerate.
27	0	Coarse conglomerate and ironstone bands.
27	0	Sandstone and conglomerate.
11	0	Soft chert and shale.
34	0	Chert and sandstone.
3	0	Conglomerate and ironstone bands.
18	0	Sandstone, and conglomerate.
1	0	Shale and coal. } Top, or "Katoomba," Coal-seam.—J.E.C.
3	6	Coal and shale.
36	0	Chert and sandstone.
		Dirty coal seam.
		……………………………………………
92	3	Blue shales, sandstones, cherts and sandstones.
141	5	Shales and sandstones
22	0	Fine conglomerate. (Marangaroo (?).- J.E.C.)
3	0	Blue shale.
76	6	Shales and sandstones.
0	2	Coal band.
23	10	Shales and sandstones.

Chocolate shales.—J.E.C.

ft.	in.		
6	0	Chocolate clay	..1
6	0	Grey shale.	
6	4	Sandstone.	
8	0	Chocolate shale	..2
3	0	Grey shale.	
5	0	Chocolate clay	..3

Dirty coal-seam.—J.E.C.

3	0	Shale.
2	0	Chert.
0	0	Coal.
1	4	Shale.
0	6	Chert.
5	0	Shale and coal bands.
2	2	Cherty shale.
22	0	Cherts and sandstones.
6	0	Shale and sandstone.
8	0	Shales.
4	0	Shale and coal bands.
7	0	Black shale.
10	0	Coarse sandstone.
1	0	Shale and coal bands.
1	0	Chert.
10	10	Shale and coal bands.
0	6	Chert.

Clarence Bore.—Situated at the head of Dargan's Creek, alongside the Great Western Railway, about one and a half miles from Clarence Station. Surface elevation, about three thousand five hundred and eight feet above sea-level. Drilled one thousand and forty feet six inches.

The plateau series (Triassic) proved to be five hundred and fifty-one feet thick. The three characteristic bands of Chocolate Shale of this locality were struck at one hundred and ninety-five feet (six feet thick), two hundred and thirteen feet (eight feet), and two hundred and twenty-four feet (five feet).

The top or Katoomba Seam was struck at five hundred and fifty-one feet, the following section being recorded :—

	ft.	in.
Sandstone and conglomerate roof.		
Shale and coal	1	0
Coal	2	6
Coal and shale	0	6
	4	0

Which corresponds very closely to the Main Camp measurements, near Hartley Vale Platform.

Forty feet lower, the "second," or "Dirty," Seam was reached.

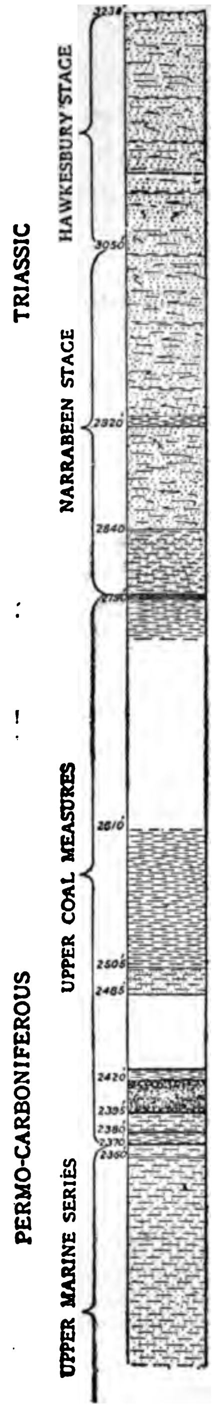
Below the latter no definite *coal* seams were recorded in the drill records, though three horizons were pierced of "shale and coal bands," down to one hundred and eleven feet below the top seam.

The most noticeable feature in this bore-record is the evident failure of the two lowest coal-seams. The natural section afforded by Grose Valley, about five miles south-eastward, however, reveals almost complete disappearance of the important "Lithgow" Seam in this direction, as will be seen by the following section :—

		ft.	in.
In descending order.	Coal mixed with bituminous shale... ...	0	6
	Clay shales and thin sandstones	8	0
	Sandstone and conglomerate	25	0
	Coal (Lithgow Seam horizon)	0	6
	Clay shales and fine sandstone	15	0
	Coal	0	5
	Bituminous shales	10	0
	Coal	0	3
	Upper Marine sandstones and shales.		

FIG. 21.—SECTION of Strata exposed in Grose Valley about 1½ miles below Hartley Vale Railway Station.

Scale, 50 feet to an inch.



Top of plateau.

Approximate level of chocolate shales.

Sandstones, with occasional thin bands of shales.

8 feet. Shales—like copper shale horizon.

Sandstone.

Shales and sandstones.

Top, or "Katoomba," Coal-seam, 5 feet to 6 feet (?) (outcrop decomposed.

Shales.

Obscured by débris.

Friable clay shales.

Shales and fine sandstones.

Obscured by débris.

ft. in.
0 6 Coal. } **Lithgow Coal-seam horizon.**
8 0 Clay shales }
25 0 Sandstone and conglomerate (Marangaroo).
0 6 Coal.
10 0 Clay shales and fine sandstones.
0 5 Coal.
10 0 Shales.
0 3 Coal.
10 0 Grose River level.

Sandstones and shales.

The natural section below Kerry and Wall's tunnels in the Katoomba Seam at Beauchamp's Falls, below Evan's Lookout, also reveals the worthless character of the lower portion of the Upper Coal Measures in that particular locality, as will be seen in the following measurements of the lowest coal outcrops :—

		ft.	in.
In descending order.	Coal seam	0	8
	Shales and sandstones	15	0
	Coal seam	1	3
	Bituminous clay shales	3	0
	Clay shales	17	0
	Marangaroo conglomerate	50	0
	Inferior coal	0	8
	Upper Marine sandstones and shales.		

Though the Lithgow Seam thins rapidly eastward—as far, at least, as beyond Evans' Lookout—south and south-east from Lithgow its diminution is more gradual, as is evident in the following section in Hartley Vale, and on the road from there to Lithgow.

In Mullen's tunnel, Reedy Creek, driven about fifty yards, the Examiner of Coal-fields recorded the following section :—

	ft.	in.
Conglomerate roof.		
Band	0	3
Coal	1	8
Shale	3	0
Coal	3	0
Stone	1	0
Coal	3	0

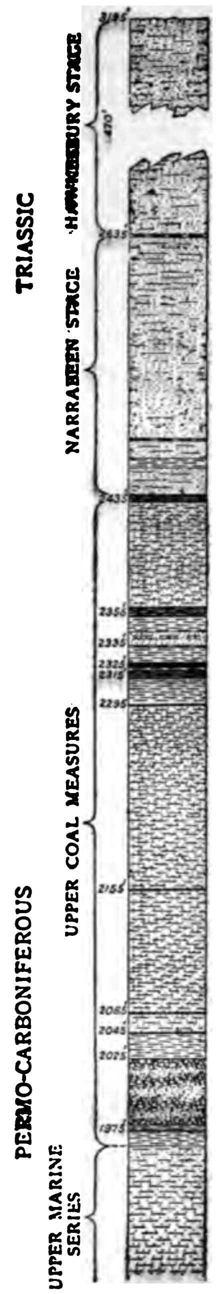
The lower three feet is reported as being good coal.

On the Hartley Vale-Lithgow road, across Hassan's Walls, the Writer measured the following section :—

	ft.	in.	
Coal seam (black dirt) thin.			
Clay shales	4	0	
Sandstone and conglomerate ...	8	0	(roof)
Coal	1	0	8 ft. 4 in
Coaly shale	1	9	
Splint and bituminous coal	5	6	

Fig 22.—Section opposite Evans' Lookout, near Blackheath.

Scale, 50 feet to an inch.



ft.	in.	
		Top of cliffs.
470	0	Sandstones, with occasional shale bands.[1]
3	6	Shales, like copper shales.
157	0	Banded sandstones, with occasional shales.
		Shale.
15	0	Sandstone.
8	0	Shales.
20	0	Sandstone.
5	0	to 6 feet. Top coal-seam (see section).
80	0	Shales and fine sandstones.
8	0	"Dirty Seam," coal and bands.
10	0	Shales, partly bituminous.
10	0	Cherts and sandstones.
2	0	Hard carbonaceous shale.
8	0	Soft clay shales, with harder bands.
3	6	Coal seam.
2	0	Shales.
8	0	Coal and bands.
20	0	Friable clay shales.
		Thin coaly outcrop.
140	0	Chiefly shales (crumbling on exposure) and sandstones
1	6	Hard sandstone.
93	6	Shales and sandstones.
0	8	Coal seam.
14	4	Shales and sandstones.
1	3	Coal seam.
20	0	Clay shales, upper 3 feet bituminous.
50	0	Marangaroo conglomerate and sandstones.
4	0	Clay shales.
0	9	Coal.
		Shaly sandstones.

The Lithgow Seam has been opened to the south-east of Victoria Pass, near Mount Victoria—in Portion 150, Parish Hartley, County Cook—where it proved two feet one and a half inches thick.

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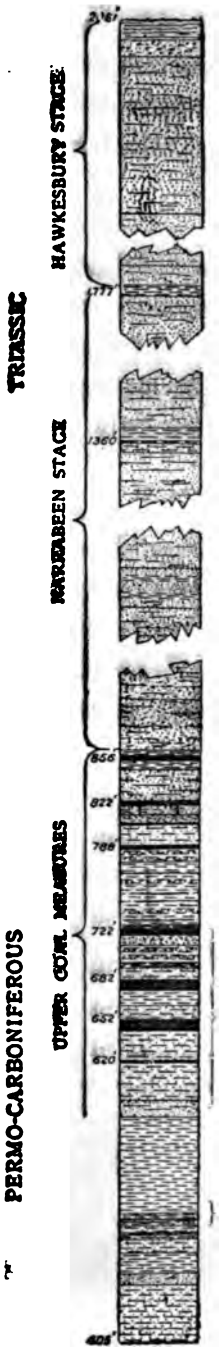
[1] A tourist track recently cut down the face of these rocks above Beauchamp's Falls, exposed a good section of the Chocolate Shales.

The most eastern opening of this seam in the Blue Mountains is Wall's Tunnel, in M.P. 3, Parish Megalong, County Cook, south-south-east of Katoomba, where a thickness of seven feet of coal and bands is recorded by Professor David (see page 189).

FIG. 23.—SECTION at No. 1 Bore, Woodford—prepared from Diamond-Drill Boring Records. Ann. Repts. Dept. of Mines, 1888 and 1889.

Scale, 50 feet to an inch.



ft.	in.		
		Surface.	
16	0	Standpipe in alluvial.	
13	3	Sandstone and conglomerate.	
		Level of mottled purple shales, determined by Professor David from drill-cores.	
254	10	Sandstone and conglomerate, with grey and chocolate shale partings.	
		Level of Chocolate shales 8 ft. 8 in. (determined in No. 2 Bore section).	
407	10	Sandstones, with shale bands.	
9	0	Blue shale.	
		Chocolate shales, 3 feet (determined in No. 2 Bore).	
10	0	Shale and sandstone.	
219	11	Sandstone and conglomerate.	
30	0	Sandstone and shale bands.	
239	6	Sandstone, shale, and conglomerate.	
4	7	Dark shale	
3	11	Coal, good. Top Seam, or "Katoomba" Seam.	
7	0	Dark shale	
23	4	Sandstone.	
3	6	Coal seam	Coal, good .... 3 ft 1½ in Band .... 0 ft 0½ in Coal, good .... 1 in Coal, hard .... 0 ft 3 in 3 ft 6 in
7	1	Sandstone.	
8	8	Chert.	
1	6	Coal, good.	
15	7	Sandstone and shale.	
3	3	Coal seam	Coal, 2 in.; band, 2 in.: coal 5 in.; band, 1 in.; coal, 3 in band, 2 in.; coal, 4 in.; band, 4 in.; coal, 1 ft. 4 in. Total, 3 ft. 3 in.
11	1	Dark shale and hard chert.	
47	11	Dark shale, with coal and cherty partings.	
3	5	Shale and coal pipes.	
4	6	Coal splint.	
8	7	Chert	
13	1	Shale and chert	
4	11	Dark shale and coal pipes.	
9	3	Dark shale and sandstone.	
7	7	Coal seam	Coal, ½ in.; band, 1½ in.; coal, 2 ft. 4 in.; band, ¾ in.; hard coal, 9½ in.; coal and bands, 4½ in.; coal, good, 1 ft. 6 in band, 2½ in.; coal, good, 1 ft. 6½ in. Total, 7 ft. 3 in.
12	0	Dark shale.	
10	5	Sandstone and shale.	
8	8	Coal seam, with bands	Band, 4 in.; coal, 1 ft. 3 in.; band, 2 ft. 8 in.; coal 10 in.; band, 4 in.; coal, 5 in.; band, 10 in.; coal, 2 ft. Total, 8 ft. 8 in.
23	0	Sandstone and shale.	
2	0	Splint coal.	
28	4	Sandstone and shale.	
13	3	Fine sandstone.	
73	0	Dark shale.	
5	0	Shale and ironstone bands.	
5	0	Shales and sandstone, with coal band.	
5	0	Shales and sandstones.	
5	0	Shale and sandstone, with coal band.	
10	0	Shale and sandstone.	
15	5	Dark shale.	
9	0	Hard grey rock	
44	6	Dark shale and shaly sandstone.	

WOODFORD NOS. 1 AND 2 BORES.

It is regrettable that stratigraphical determinations in these most eastern bores on the Blue Mountains should, apparently, have been left to the drill foreman. Bands of cinnabar (?) are recorded, which probably refer to ironstone. Several seams of Kerosene Shale are also described, but no attempt was made to verify or test the cores—a serious omissión. It is possible that this substance may have been proved at Woodford, but the number and aggregate thickness of the seams is more than doubtful.

The Coal Measures in these bores have an aggregate thickness of about two hundred feet only, but contain the full complement of coal-seams—seven, or perhaps eight. The first, or "Katoomba," seam, however, shows considerable diminution in thickness as compared with the sections exposed in Kerry's tunnels at Evans' Lookout, two feet seven inches only being recorded in the Woodford Bores.

The latter are about thirty chains apart; difference in surface level places the first coal-seam in them at one thousand one hundred and ninety-four and one thousand two hundred and thirty feet below the surface; the lowest, or "Lithgow," seam at one thousand three hundred and eighty-four and one thousand four hundred and nine feet respectively. Considerable depreciation is evident in the latter seam, as will be seen from the sections:—

"Lithgow Seam" No. 1 Bore.

	ft.	in.
Coal, splint	1	3
Fireclay	2	8
Coal, splint	0	10
Fireclay	0	4
Coal	0	5
Fireclay	0	10
Coal	2	0
	8	4

"Lithgow Seam" No. 2 Bore.

	ft.	in.
Coal	0	3
Soft chert	0	7
Splint coal	1	3
Chert	2	7
Splint coal	1	2
Soft chert	1	1
Coal, with two bands	1	0
	7	11

At twenty-two and a half feet in No. 1 Bore, and thirty-one and a half feet in No. 2, above the "Lithgow," a more compact seam was pierced, which probably corresponds with the "Upper Irondale." The following sections are recorded:—

"Upper Irondale" No. 1 Bore, Woodford.	ft.	in.
Coal	0	0½
Band	0	1½
Coal, splint and bituminous ...	2	4
Dark band	0	4
Hard coal	0	9½
Coal and bands...	0	4½
Coal, good splint	1	6
Hard band	0	2½
Coal, good splint and bituminous	1	6½
	7	3

"Upper Irondale" No. 2 Bore, Woodford.	ft.	in.
Coaly shale	0	6
Ironstone	0	4
Coal, inferior	2	1
Hard band	0	1
Coal	1	6
Band	0	1
Coal, good	1	2
Band	0	0½
Coal	0	9
	6	6½

At twenty-seven feet four inches in No. 1 Bore, and twenty-four feet six inches in No. 2, below the top, or "Katoomba," seam, a three feet six inches seam was pierced a little above the horizon of the "Dirty Seam;" this corresponds with the second, or Four-foot, seam of the Southern Coal-field.

Samples of coal cores from the latter and from the "Main" seam were submitted for analysis.[1] It is evident from the measurements accompanying them that the seam immediately above the bottom, or "Lithgow," seam was regarded as the "Main."

PROXIMATE Analyses, by H. P. White.

No. 2 Bore, Woodford.	Portion of Seam.	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Coke.	Specific Gravity.	No. of Analysis.
"Main" Seam, 1,346 ft. level.	Top	1·37	23·68	43·10	31·85	·6	74·95	1·543	1889. 1230
" " ...	Middle 1 ft. 6 in.	1·21	27·64	55·15	16·00	·837	71·15	1·382	1229
" " ...	Bottom 1 ft. 6 in.	1·28	25·82	55·85	17·05	·998	72·9	1·391	1228
No. 2 Seam, 1,221 ft. level.	3 ft. 4 in. thick	1·22	27·78	58·35	12·65	·59	71·	1·318	1231

Coke. { Analysis No. 1228.—Fairly well swollen, bright, and firm. Ash, dark grey.
" 1229.—Well swollen, bright and firm. Ash, dark grey.
" 1230.—Fairly well swollen, bright and firm. Ash, dark grey.

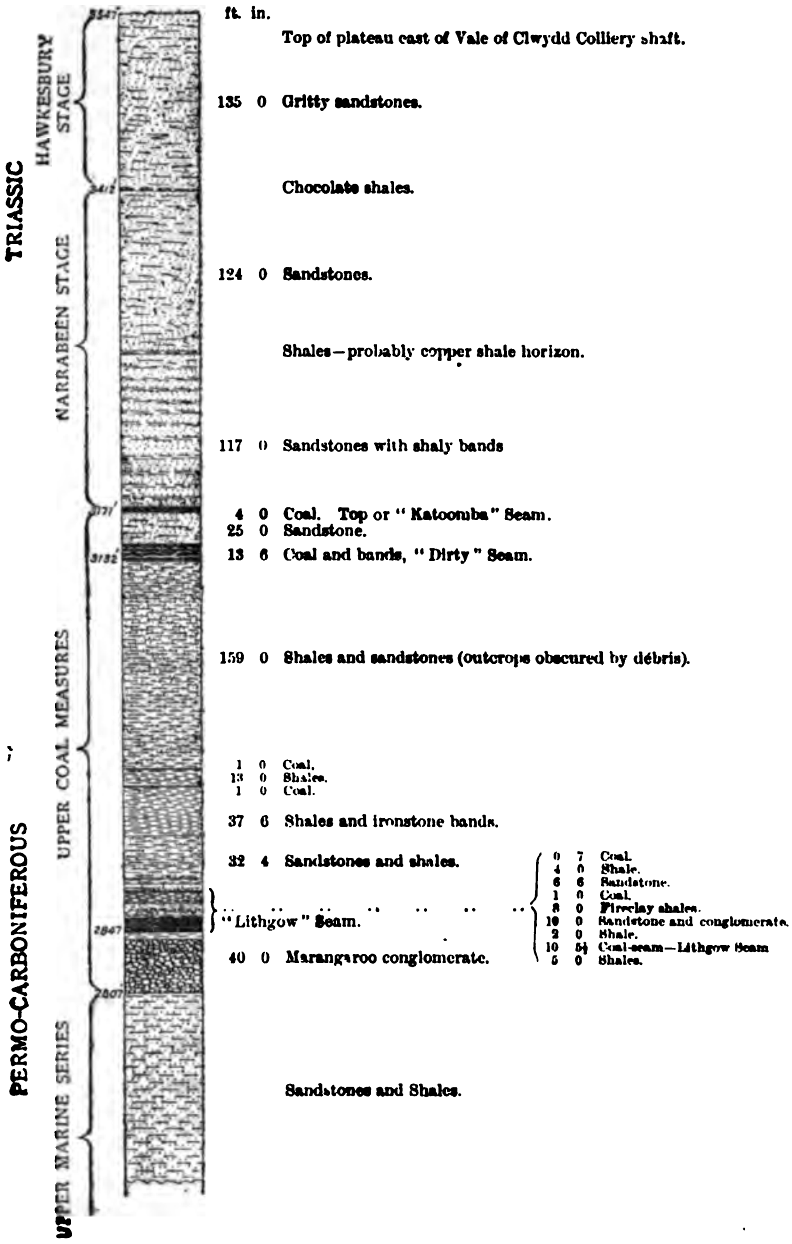
---

[1] Ann. Rept. Dept. Mines for 1889, p. 33.

The Euroka and Breakfast Creek bores near Penrith have been described by Professor David.[1]

FIG. 24.—SECTION (C) east of Vale of Clwydd Colliery, Lithgow Valley, in part after J. Mackenzie.

(Mineral Products N. S. Wales, 1887, Plan 20.)
Scale 50 feet to an inch.


TRIASSIC
HAWKESBURY STAGE
NARRABEEN STAGE
PERMO-CARBONIFEROUS
UPPER COAL MEASURES
UPPER MARINE SERIES
3547'
3412'
3171'
3132'
2847
2807'
ft. in.
Top of plateau east of Vale of Clwydd Colliery shaft.
135 0 Gritty sandstones.
Chocolate shales.
124 0 Sandstones.
Shales—probably copper shale horizon.
117 0 Sandstones with shaly bands
4 0 Coal. Top or "Katoomba" Seam.
25 0 Sandstone.
13 6 Coal and bands, "Dirty" Seam.
159 0 Shales and sandstones (outcrops obscured by débris).
1 0 Coal.
13 0 Shales.
1 0 Coal.
37 6 Shales and ironstone bands.
32 4 Sandstones and shales.
"Lithgow" Seam.
40 0 Marangaroo conglomerate.
0 7 Coal.
4 0 Shale.
6 6 Sandstone.
1 0 Coal.
8 0 Fireclay shales.
10 0 Sandstone and conglomerate.
2 0 Shale.
10 5½ Coal-seam—Lithgow Seam
5 0 Shales.
Sandstones and Shales.

---

[1] Ann. Rept. Dept. Mines for 1889, pp. 229-230.

Description of Coal-seams.

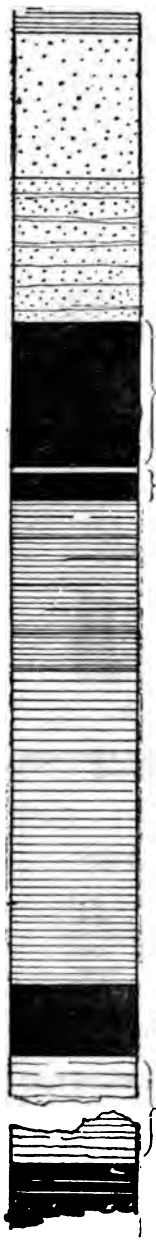
No. 1. Top or "Katoomba" Seam opened at Katoomba by Mr. J. B. North in 1878.[1] Colliery started in 1882 (17 on Plan of Western Coal-field).

Opened by tunnel under plateau escarpment about eight hundred feet below the Great Western Railway at Katoomba, and six hundred and twenty-five feet below top of vertical cliffs at the engine bank. When at work, the coal was conveyed to the railway by an incline and endless tramway cable two miles in length.

Northerly and easterly the workable coal thins considerably, but maintains a workable thickness to north, west, and south-west.

Thickness and quality of south-west face are shown in the following section and analyses :—

Fig. 25.


ft. in.
Shales and shaly sandstones.
3 0 Sandstone.
3 0 Fine-grained banded sandstones.
Katoomba seam.
3 0 Coal ..
0 1½ Band.
0 7 Coal ..
3 6 Stony carbonaceous es with coal streaks (floor).
6 6 Blue shales.
1 6 Coal. (4ft. seam of Southern Coal-field.)
About 50 feet to "Dirty" Seam.
"Dirty" Seam.

No. 1412—

Hygroscopic moisture	1·73	
Volatile hydrocarbons	27·22	
Fixed carbon	60·32	Coke, 71·05
Ash	10·73	
	100·00	

No. 1413—

Hygroscopic moisture	1·95	
Volatile hydrocarbons	26·75	
Fixed carbon	57·65	Coke, 71·30
Ash	13·65	
	100·00	

No. 1414—Average sample from main tunnel, exclusive of bands.

Hygroscopic moisture	2·58	
Volatile hydrocarbons	25·80	
Fixed carbon	59·80	Coke, 71·62.
Ash	11·82	
	100·00	

No. 1412—Coke, slightly swollen, firm, dull lustre.
Ash, grey, granular.
Sulphur in coal .... 0·508 %
Specific gravity .... 1 392 %
Calorific power .... 11·6 lb.

No. 1413—Coke, slightly swollen, firm, dull lustre.
Ash grey, granular.
Sulphur in coal .... 0·412 %
Specific gravity .... 1·369 %
Calorific power .... 11·7 lb.

No. 1414—Coke, slightly swollen, firm, dull lustre.
Ash, light grey, granular.
Sulphur in coal .... 0·439 %
Calorific power .... 11·6 lb.

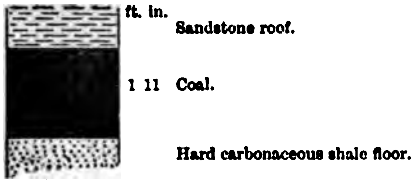
---

[1] Min. Prod. N. S. Wales, 1887, p. 156.

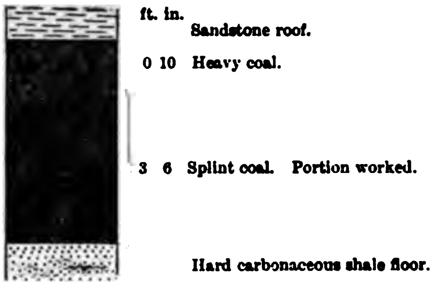
No. 1 "**Katoomba**" **Seam**, opened by the New South Wales Shale and Oil Company, at Main Camp Colliery, alongside the Great Western Railway, near Hartley Vale Platform (20 on Map of Western Coal-field).

Fig. 26.—(Sections after Mackenzie, Ann. Rept. Dept. Mines for 1886, pp. 121, 122.) Not working.

Bottom of Shaft, 512 feet deep.



345 yards in heading north-west of Shaft.


ft. in.
Sandstone roof.
0 10 Heavy coal.
3 6 Splint coal. Portion worked.
Hard carbonaceous shale floor.

410 yards in heading north-west of Shaft.

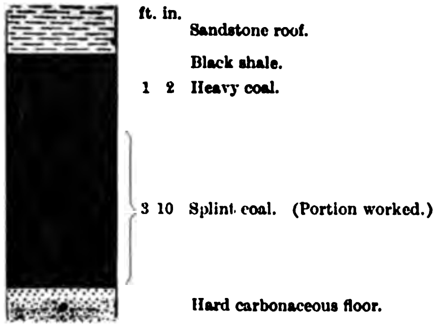
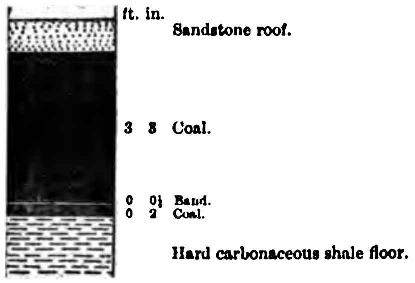


Fig. 27.—No. 1 "Katoomba" Seam, opened by the New South Wales Shale and Oil Company, Hartley Vale. (*See* 20 Map Western Coal-fields)

Woodburn's Tunnel, Potato Gully, Hartley Vale.



Proximate Analysis, by W. A. Greig.

No. 5286 (exclusive of bands)—

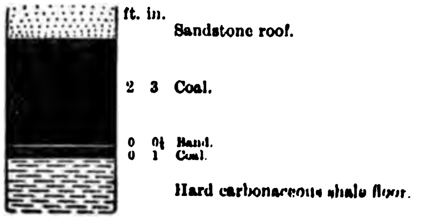
Hygroscopic moisture	14·37
Volatile hydrocarbons	27·33
Fixed carbon	46·91
Ash	11·39
	100·00

No true coke. Ash, white, granular.

Sulphur in coal	0·302 %
Specific gravity	1·528

Note.—Short prospecting tunnel only; excessive hygroscopic moisture, due to partial weathering of the coal.

New Road Tunnel, near Hartley Vale Railway Station.



Proximate Analysis, by W. A. Greig.

No. 5287 (exclusive of band)—

Hygroscopic moisture	2·10
Volatile hydrocarbons	25·90
Fixed carbon	58·95
Ash	13·05
	100·00

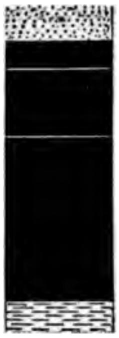
Ash, white, semi-granular.

Sulphur in coal	0·357 %
Specific gravity	1·418
Calorific power	11·4

Worked in connection with the Oil Refinery at Hartley Vale.

FIG. 28.—No. 1 "KATOOMBA" SEAM, opened by prospecting tunnel for 120 feet by H. G. Rienits and others, Victoria Falls Creek, near Mount Victoria.

(Section near mouth of tunnel) in ML 154, Parish Blackheath, County Cook.



ft.	in.	
		Sandstone roof.
0	7	Bituminous coal.
0	0½	Band.
1	4½	Hard coal.
0	0½	Band.
3	5½	Hard coal.
		Hard carbonaceous shale floor.

Proximate Analysis, by W. A. Greig.

No. 5238 (exclusive of bands)—

Hygroscopic moisture	1·80
Volatile hydrocarbons	24·15
Fixed carbon	54·33
Ash	19·72
	100·00

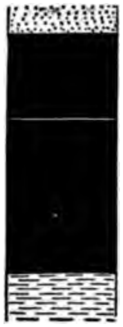
Ash, white, semi-granular.

Sulphur in coal	0·370
Specific gravity	1·449
Calorific power	10·5

NOTE.—An average of ten analyses of different samples made for the prospectors equalled 17·9 per cent. of ash.

FIG. 29.—No. 1 "KATOOMBA" SEAM, opened by tunnel in south bank of Grose Valley by Mackenzie and Garrett, near Mount Victoria (unworked).

ML 10, Parish Blackheath, County Cook.—(Section near mouth of tunnel.)



ft.	in.	
		Sandstone roof.
1	9½	Coal.
0	0¾	Band.
3	3	Coal.
		Hard carbonaceous shale floor.

Proximate Analysis, by W. A. Greig.

No. 5289 (exclusive of bands)—

Hygroscopic moisture	3·78
Volatile hydrocarbons	25·27
Fixed carbon	54·52
Ash	16·42
	100·00

No true coke.

Ash, grey in colour, semi-granular.

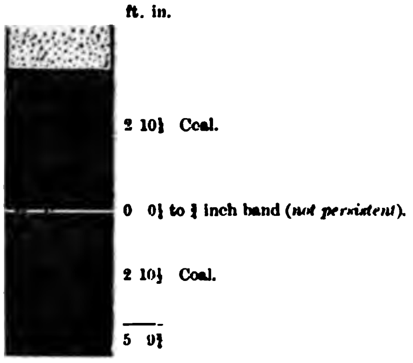
Sulphur in coal	0·260 %
Specific gravity	1·403
Calorific power	10·4

Top (Katoomba) seam in portion 452, Parish Blackheath, County Cook, on north side of Grose Valley. Slightly opened by P. Winchester about twenty years ago, for Mackenzie and Garrett, in prospecting drive only. Reopened by D. Wilkins and others in 1907, and extended one hundred and twenty feet.

Near entrance of tunnel the seam has a thickness of five feet nine and three-quarter inches, including a three-quarter inch band which divides it equally. At about one hundred feet the section measured five feet eight inches without any perceptible band, the latter evidently not being persistent.

An average sample carefully chipped from the full thickness in two places in the tunnel, and carefully broken and mixed, yielded the following results on analysis :—

Fig. 30.—Section in Wilkins and Party's Tunnel, north side of Grose Valley.



Proximate Analysis by H. P. White.

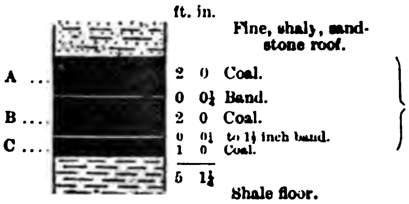
No. 07·6953 (exclusive of band)

Hygroscopic moisture	1·72
Volatile hydrocarbons	29·02
Fixed carbon	56·69
Ash	12·57
	100·00

Coke	69·26	Coke—Slightly swollen, firm, fairly lustrous. Ash—White granular.
Sulphur	0·447	
Specific gravity	1·402	
Calorific power	12·0	

Fig. 31.—Kerry and Party's Coal Tunnels in Top Seam, near Beauchamp's Falls, under Evan's Lookout, (MP 5, Parish Blackheath, County Cook).

Section in No. 1 Tunnel.



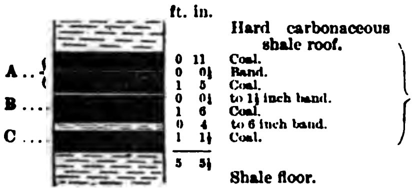
Average sample taken from 3 feet from mouth of tunnel (including upper band).

No. 4807—05.

Proximate Analysis by W. A. Greig.

Hygroscopic moisture	0·89
Volatile hydrocarbons	26·53
Fixed carbon	55·66
Ash	16·92
	100·00
Sulphur	0·370 %
Specific gravity	1·428
Calorific power	11·4

Section in No. 2 Tunnel.



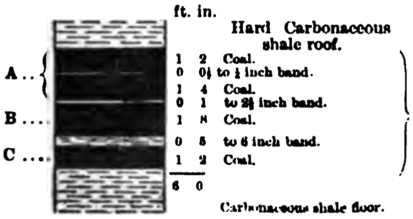
Average sample taken 6 feet from tunnel mouth (exclusive of lower band only).

No. 4806—05.

Proximate Analysis by W. A. Greig.

Hygroscopic moisture	3·71
Volatile hydrocarbons	23·95
Fixed carbon	54·83
Ash	17·51
Sulphur	0·302 %
Specific gravity	1·506
Calorific power	9·7

ection in No. 3 Tunnel.



Average sample from 30 feet from mouth of tunnel (exclusive of two principal bands).

No 4805—05.

Proximate Analysis by W. A. Greig.

Hygroscopic moisture	0·69
Volatile hydrocarbons	24·64
Fixed carbon	55·61
Ash	19·06
	100·00
Sulphur	0·28 %
Specific gravity	1·467
Calorific power	10·7

By exclusion of all bands, probably a difference of 1 per cent. less ash might be attained.

To determine the value of each portion of the seam separately fresh average samples were carefully taken from the inner faces in Tunnels No. 2 and No 3, representing the divisions A, B, and C; the thin band in A being eliminated as it is not persistent.

Proximate Analysis.	07·6952 A.	07·6951 B.	07·6950 C.	Remarks.	Analyst.
Hygroscopic moisture	1·85	1·68	1·68	A. Coke—Slightly	H. P. White.
Volatile hydrocarbons	27·83	24 62	22 90	swollen, firm,	......
Fixed carbon	57·45	52·36	52·51	dull lustre.	......
Ash	12·87	21·34	22·91	B. Coke—73·70	......
	100 00	100·00	100·00	C. Coke—75·42	......
				....	......
Sulphur in coal	0·516	......	......	....	......
Specific gravity	1·402	......	......	....	......
Calorific	11·60	......	......	....	......
Coke	70·32	......	......	....	.. ...

No output—prospecting tunnels only.

The average composition of the Katoomba seam from eight provings works out as follows:—

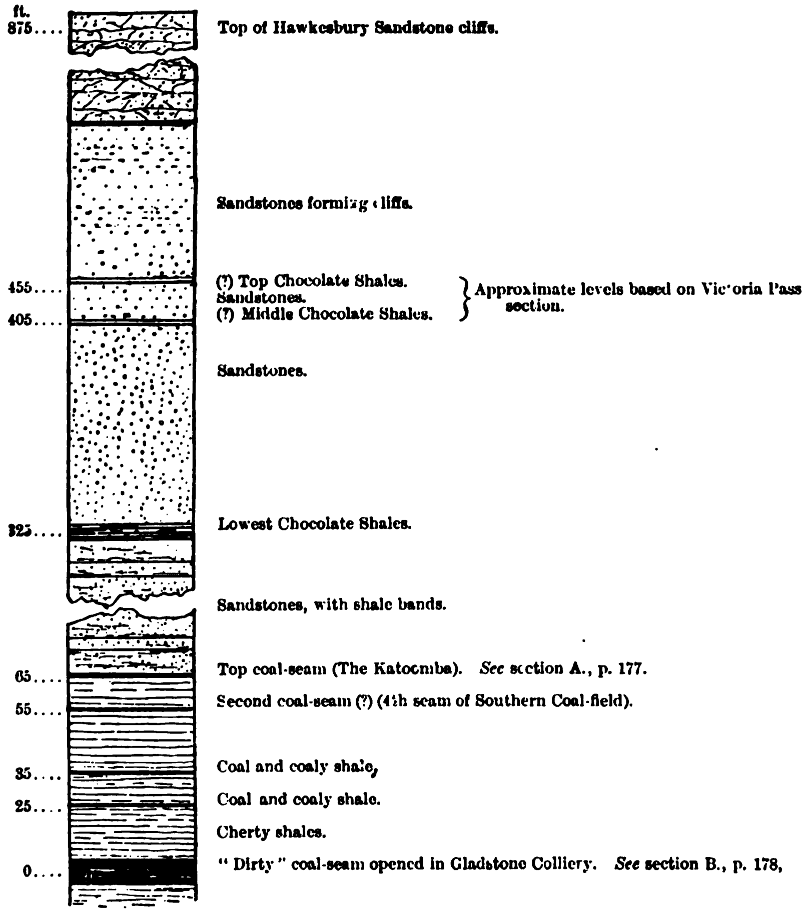
Hygroscopic moisture	2·10
Volatile hydrocarbons	26·07
Fixed carbon	56·07
Ash	15·75
	99·99

The increased thickness recorded in Grose Valley outcrops to the north-east of Mount Victoria is depreciated by higher ash contents. Wilkins and Party's tunnel on the north side of Grose Valley, however, reveals a workable seam of useful quality extending north and north-north-west. Though much thinner on the rise of the seam at Katoomba and Hartley Vale Collieries, the quality is slightly better, as shown in the following average of three samples taken from those workings:—

Hygroscopic moisture	2·13
Volatile hydrocarbons	26·30
Fixed carbon	59·69
Ash	11·86

This result is a shade superior to the Lithgow seam average, whilst the steaming properties—represented by the fixed carbon—should be five per cent. better.

FIG. 32.—SECTION at the Valley of the Waters, near Wentworth Falls.


ft.
875....
Top of Hawkesbury Sandstone cliffs.
Sandstones forming cliffs.
455....
(?) Top Chocolate Shales.
Sandstones.
(?) Middle Chocolate Shales.
405....
Approximate levels based on Victoria Pass section.
Sandstones.
325....
Lowest Chocolate Shales.
Sandstones, with shale bands.
65....
Top coal-seam (The Katoomba). *See* section A., p. 177.
55....
Second coal-seam (?) (4th seam of Southern Coal-field).
35....
Coal and coaly shale,
25....
Coal and coaly shale.
Cherty shales.
0....
" Dirty " coal-seam opened in Gladstone Colliery. *See* section B., p. 178,

The second Blue Mountain seam is known as the "Dirty" seam, because of the frequent bands, and deterioration of the coal in part into carbonaceous shale.

It occurs about sixty feet below the Katoomba seam, and has a thickness up to eighteen feet or more, including bands.

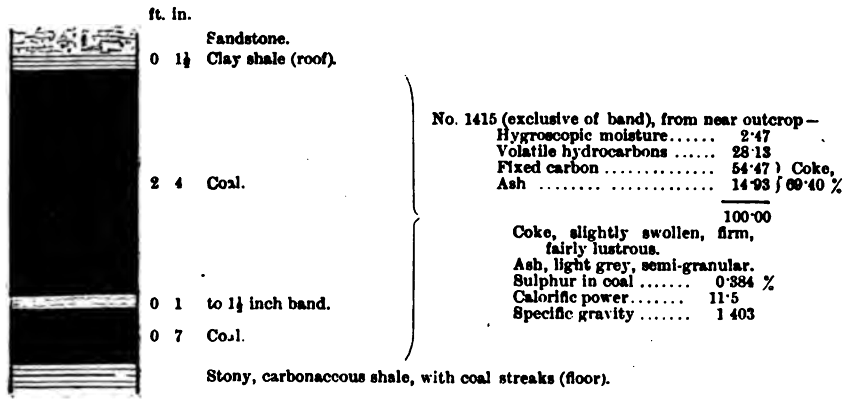
As it corresponds with the third Illawarra seam, and the latter, according to Professor David, with the workable "Great Northern" seam of the Northern Coal-field, where it has a corresponding thickness of about nineteen feet, it follows that considerable improvement in quality takes place in that direction, or in that locality.

Near Ilford (Sheet 13), and near Tayan Pic (Sheet 14), where good natural sections have been observed, a certain amount of clean coal occurs between the bands.[1] Elsewhere, however, in the Blue Mountains, it appears to be worthless, owing to deterioration into shaly material. The only attempt to work this seam was in the Gladstone Colliery, between Leura and Wentworth Falls, in 1886. At the former, two tunnels were driven for a short distance into it, and connection with the railway made by means of an aerial tramway to the top of the cliffs; thence by endless cable a distance of one and three-quarter miles. After considerable expenditure, about two hundred tons of coal only were mined, which failed to secure a market. No further attempt was made to work.[2]

The following sections show the two seams opened in the Gladstone Colliery; also analyses of both:—

FIG. 33.—SECTION of Top or "Katoomba" seam, at the Valley of the Waters near Wentworth Falls.

A.



No. 1415 (exclusive of band), from near outcrop—

Hygroscopic moisture	2·47	
Volatile hydrocarbons	28·13	
Fixed carbon	54·47	Coke,
Ash	14·93	69·40 %
	100·00	

Coke, slightly swollen, firm, fairly lustrous.
Ash, light grey, semi-granular.

Sulphur in coal	0·384 %
Calorific power	11·5
Specific gravity	1·403

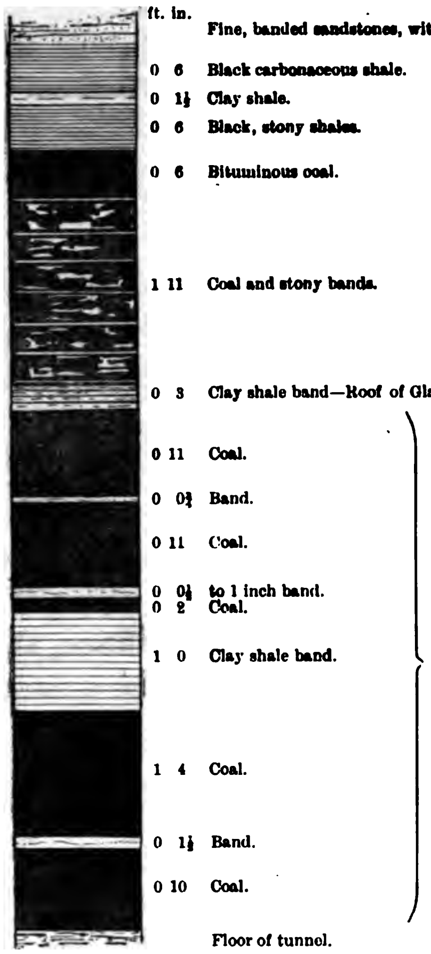
---

[1] See Analysis of upper portion of Seam in Wolgan Valley near Newnes, p. 254.

[2] Min. Prod. N. S. Wales, 1887, p. 156.

FIG. 34.—SECTION of "Dirty" seam, at outcrop in tunnel below Valley of the Waters (opened in Gladstone Colliery).

B.



No. 1416 (sample, exclusive of bands)—

Hygroscopic moisture......	7·17
Volatile hydrocarbons......	23·10
Fixed carbon	46·79
Ash	22·94
	100·00

No true coke.
Sulphur in coal .... 0·384 %
Specific gravity .... 1·579

The following section was measured in Bates' Tunnel, Portion 21, Parish Kadumba, County Cook, under King's Tableland, south of Wentworth Falls :—

	ft.	in.
Clay shale roof.		
Stony coal and clay shale ...	1	0
Clay shale	0	2
Coal	0	6
Clay shale	0	2
Coal	0	10
Clay shale	0	2½
Coal	0	11½
Clay shale	0	0½–¾
Coal	0	2½
Clay shale	0	1½
Coal	0	5
Clay shale	0	0¼
Coal	0	7
Coaly and clay shales ...	0	8
Coal	1	3
Clay shale	0	2½
Coal	0	7
Clay shales	0	0½
Coal	1	0
Clay shales	0	1
Coal	1	10
Clay shale	0	1
Stony coal	0	7
Clay shales	0	3
Stony coal and clay shales ...	1	0

In 1859, whilst a track was being cut along the course of the Grose River for the purpose of ascertaining the possibility of railway construction, the "Dirty" coal-seam was discovered, where it makes a prominent outcrop in the river bank. The officer—Sergeant Quodling—in charge of the sappers cutting the track, reported to the Commissioner for Lands, under date, Parramatta, 19th December, 1859 :—"I have the honour to report that a considerable seam of good coal is outcropping at a point on the River Grose, distance twenty-three miles from its confluence with the River Nepean, and nineteen miles from the Darling Causeway, and that there is a large quantity of land available for agriculture, commencing about midway on the River Grose, and extending upwards for several miles.—(Parliamentary Report, *The Empire*, Dec. 21st, 1859.)

In 1881 the land hereabouts was taken up by Wrench and others under lease for coal-mining. Portions 91–4, Parish Grose, County Cook. The site is about three and a half miles below Mount Hay, near where the Coal Measures disappear below the river-bed, its lower course being through the Hawkesbury Series.

The following section was measured by the Writer in November, 1904 :—

	ft.	in.	
Sandstone cliffs.			
Cherts sandstones and shales	60	0	
Top Coal-seam (Katoomba)	1	0	
Clay shales and sandstones	34	6	
Coal	0	7	
Hard band	0	3	
Coal	0	6	
Hard clay shale	0	8	
Soft clay shale	0	3	
Red shale	0	7	
Coal	1	2	
Clay band	0	3	
Coal	0	4	
Clay band	0	1	
Coal	1	3	
Hard carbonaceous shale	0	7	
Coal with bands	0	9	
Coaly shale	0	6	
Soft clay shale	1	6	Abundant fossil tree-stems.
Hard clay shale	0	3	
Coal and bands (stony)	1	0	
Coal	2	0	
River level.			

Dip east 10° south at 8½°.

SECTION of "Dirty" seam south of Tayan Pic, above Capertee Nile:—

	ft.	in.
Sandstone roof.		
Coaly shale	0	1
Clay shale	0	1½
Coal	1	2
Clay band	0	1
Coal	0	9
Clay band	0	1½
Coal	1	8
Clay band	0	1½
Coal	0	10
Clay band	0	1½
Coal	1	1
Clay band	0	2½
Coal	0	3
Clay band	0	0½
Coal	1	4
Band—parting—		
Coal	1	6
Clay band	0	2
Coal—lowest exposure.		

"Dirty" seam in Megalong Valley. D. R. Wall's 640 acres. After Professor David.[1]

ft.	in.	
		Roof—black stony shale.
1	0	Coal, splint and bituminous.
0	3	Shale, black.
0	0½	White fire-clay.
0	2	Black coaly clay, earthy and soft.
0	3½	Band, hard ; brittle black shale.
0	7	Coal, dirty, soft, and splint, mixed.
0	4	Band, hard black shale.
0	9	Coal, dirty splint.
0	3	Band, dark brown clay ; rather intermittent.
1	11½	Coal, upper half splint; very hard; lower half, brittle and bituminous
0	4½	Band, yellowish-grey fire-clay.
1	5	Coal, chiefly splint; some brittle black bituminous; rather dirty; a trifle soft in upper 4 in.
0	2	Band, brown clay.
1	5	Coal, chiefly splint, rather dirty.
9	0	

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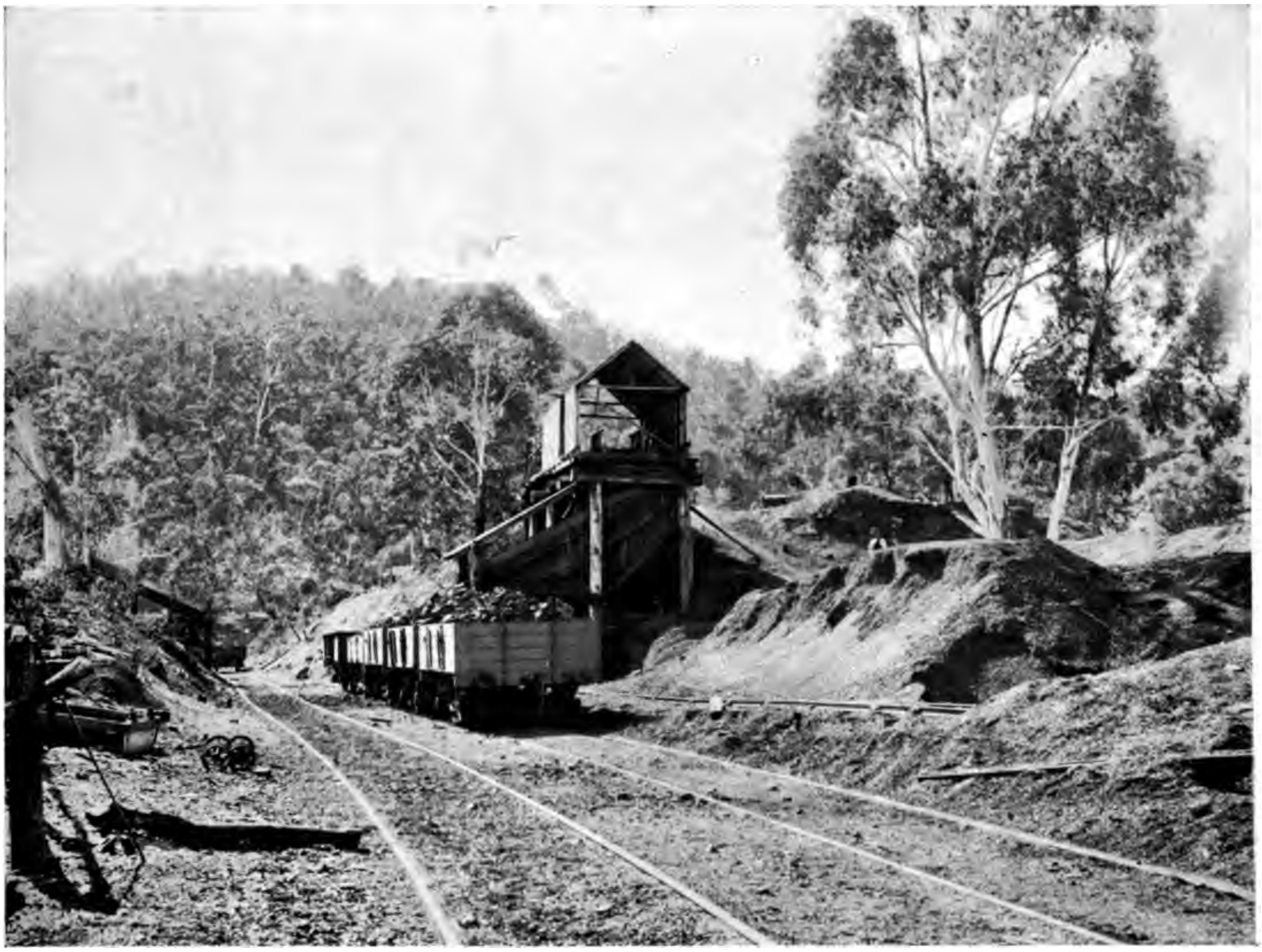
[1] Ann Rept. Dept. Mines for 1890, p. 222.

PLATE XVI.

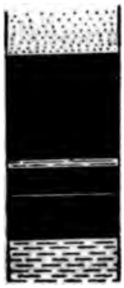


Govt. Printer.

IRONDALE COLLIERY PIPER'S FLAT (LOADING STAGE).

The upper seam (*A*), worked at Irondale, is represented by the following section, measured at about six chains from the tunnel entrance. An average sample, taken from the full thickness (exclusive of bands), yielded the results recorded with the section.

FIG. 36.



ft.	in.	
		Sandstone roof.
2	3	Coal, bright, bituminous.
0	2	Band.
0	7	Coal, bright, bituminous.
0	½	Parting, black band.
0	11	Coal, hard, splinty.
3	11½	

Approximate Analysis by W. A. Greig.

No. 4252.

Hygroscopic moisture	3·19
Volatile hydrocarbons	33·87
Fixed carbon	47·81
Ash	15·13
	100·00

Coke, 62·94 per cent., fairly well swollen, fairly firm, lustrous.

Sulphur in coal	0·549 per cent.
Specific gravity	1·367

Ash : Nearly white, semi granular.

Calorific power : 1 lb. of this coal will convert 11·5 lb. of water into steam.

Near the entrance to the tunnel the seam has a thickness of about five feet, and in the direction of the Ivanhoe Colliery it increases to over six feet.

The analysis given above included all the coal. In winning, the stonier portions of the lower band are discarded from the lump coal. The following analyses, by W. A. Greig, represent samples taken at random from several skips awaiting dispatch :—

No. 2222.—Coal from upper portion of seam—

Hygroscopic moisture	3·20
Volatile hydrocarbons	35·46
Fixed carbon	47·03
Ash	14·31
	100·00

No. 2223.—Coal from bottom holing (lower 11 inches)—

Hygroscopic moisture	3·61
Volatile hydrocarbons	33·16
Fixed carbon	47·12
Ash	16·11
	100·00

The average composition of the upper seam at Irondale, based on four average samples taken in different headings at two different periods, is as follows :—

Proximate Analysis.

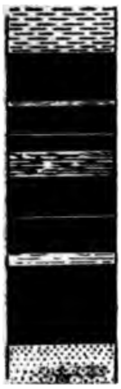
Hygroscopic moisture	2·95
Volatile hydrocarbons	33·98
Fixed carbon	47·87
Ash	15·20
	100·00
Sulphur in coal	·512
Specific gravity	1·375
Calorific power	11·3

If the bottom holing coal be discarded, the average ash contents will be reduced one per cent.

PORTLAND COLLIERIES (22 on map of Western Coal-field).

The face of the upper tunnel at Portland, at one hundred and twenty feet, in from the outcrop of the Upper Irondale seam, yielded the succeeding section.

FIG. 37.



ft.	in.	
		Sandstone roof.
1	8	Coal, bright, bituminous.
0	3	Band.
0	9	Coal, bright, bituminous.
0	0½	Band.
0	10½	Coal, bright, bituminous.
0	6½	Coal and band mixed.
0	4½	Coal.
0	1	Band.
0	7	Coal.
0	1½	Band.
1	0	Coal (friable).
6	3½	
		Carbonaceous shale floor.

Proximate Analysis—W. A. Greig.

No. 4249.

Hygroscopic moisture	6·06
Volatile hydrocarbons	29·26
Fixed carbon	50·70
Ash	13·98
	100·00

Coke : No true coke formed ; slightly coked only.
Sulphur in coal .... 0·672 per cent.
Specific gravity .... 1·432
Calorific power : 1 lb. of coal will convert 10·8 lb. of water into steam.
Ash : Nearly white, granular.

In an air shaft at the Ivanhoe Colliery the "Upper Irondale" seam was struck at sixty-two feet above the "Lithgow," the shaft passing chiefly through sandstone between the seams.

Mr. W. Burns, Colliery Manager, supplied the following particulars of the upper seam in the air shaft.

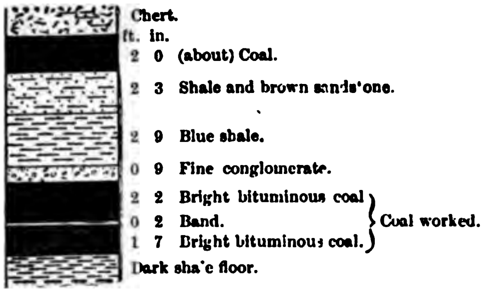
Sandstone roof—	ft.	in.
Coal ...	1	0
Band	0	2
Coal ...	1	11
Band	0	5
Coal (splint)	1	1
Coal (bright)	1	2
Band	0	2
Coal ...	1	0
	6	11

The percentage of volatile hydrocarbons in the "Upper Irondale" seam is high, and compares very favourably with the best Lithgow coal for gas-making, though the relatively larger proportion of ash in the coke has to be considered.

This seam is characterised by the brightly bituminous nature of its greater thickness. The lower band is usually stony or splinty coal.

Wallace's Black Diamond Colliery, worked in 1896; closed in July, 1902. Output, 5,995 tons.

Fig. 38.—(Section by J. Mackenzie.)[1]



Analysis of Black Diamond Coal.[2]

Hygroscopic moisture	1·85
Volatile hydrocarbons	33·55
Fixed carbon	46·65
Ash	17·95
	100·00
Sulphur	0·658
Specific gravity	1·458
Coke	64·60 per cent.

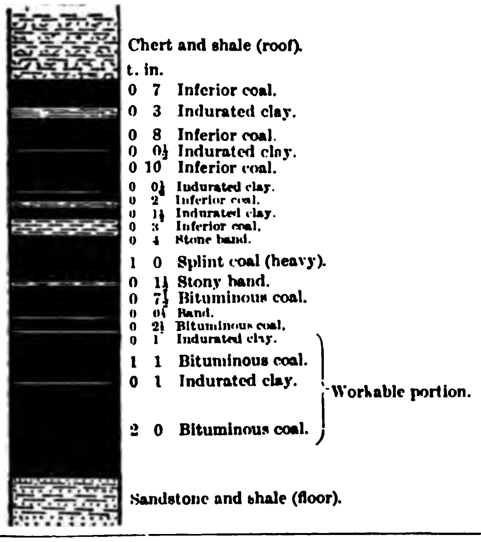
Calorific power—1 lb. of coal will convert 11·0 lb. of water into steam.

Coke—not much swollen, fairly bright, firm, covered with cauliflower-like excrescences.

Ash—white, granular.

"Upper Irondale" seam, exposed in tunnel sixty feet above the Cullen Bullen working seam (the "Lithgow"). After Mackenzie.[3]

Fig. 39.



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[1] Ann. Rept. Dept. Mines for 1895, p. 102.
[2] Mineral Resources N. S. Wales, 1901, p. 344.
[3] Ann. Rept. Dept. Mines for 1889, p. 189.

North and east in the Capertee and Grose Valleys, a thin coal-seam, eight to fourteen inches in thickness, appears below the Marangaroo, whilst the Lithgow Seam above it diminishes to an equal thinness.

From these points on strike and dip, no outcrops are visible for many miles, owing to the inclination of the strata exceeding the fall of the drainage. At Gunnedah, however, about one hundred and fifty miles northerly, the main working seam in the Black Jack and Curlewis Collieries occurs about thirty feet below a well-developed quartz-pebble conglomerate, remarkably like the Marangaroo. If it corresponds, then the seam immediately above it in the Lithgow Coal-field has disappeared at Gunnedah, whilst the underlying thin seam of Grose and Capertee Valleys has developed northerly into the excellent six-foot seam of Gunnedah and Curlewis. Detail survey of the latter field, however, is necessary to establish exact relationship.

The Marangaroo is the only conspicuous and persistent conglomerate bed in the marginal area of the Upper Coal Measures in the Western Coal-field, and, as before stated, occurs at their base.

In the roof of the Lithgow Seam, immediately in contact with the coal, pebbles are frequent in the sandstone. In places, as at Blackman's and Piper's Flats, near Wallerawang, the roof becomes wholly conglomeratic for short distances.

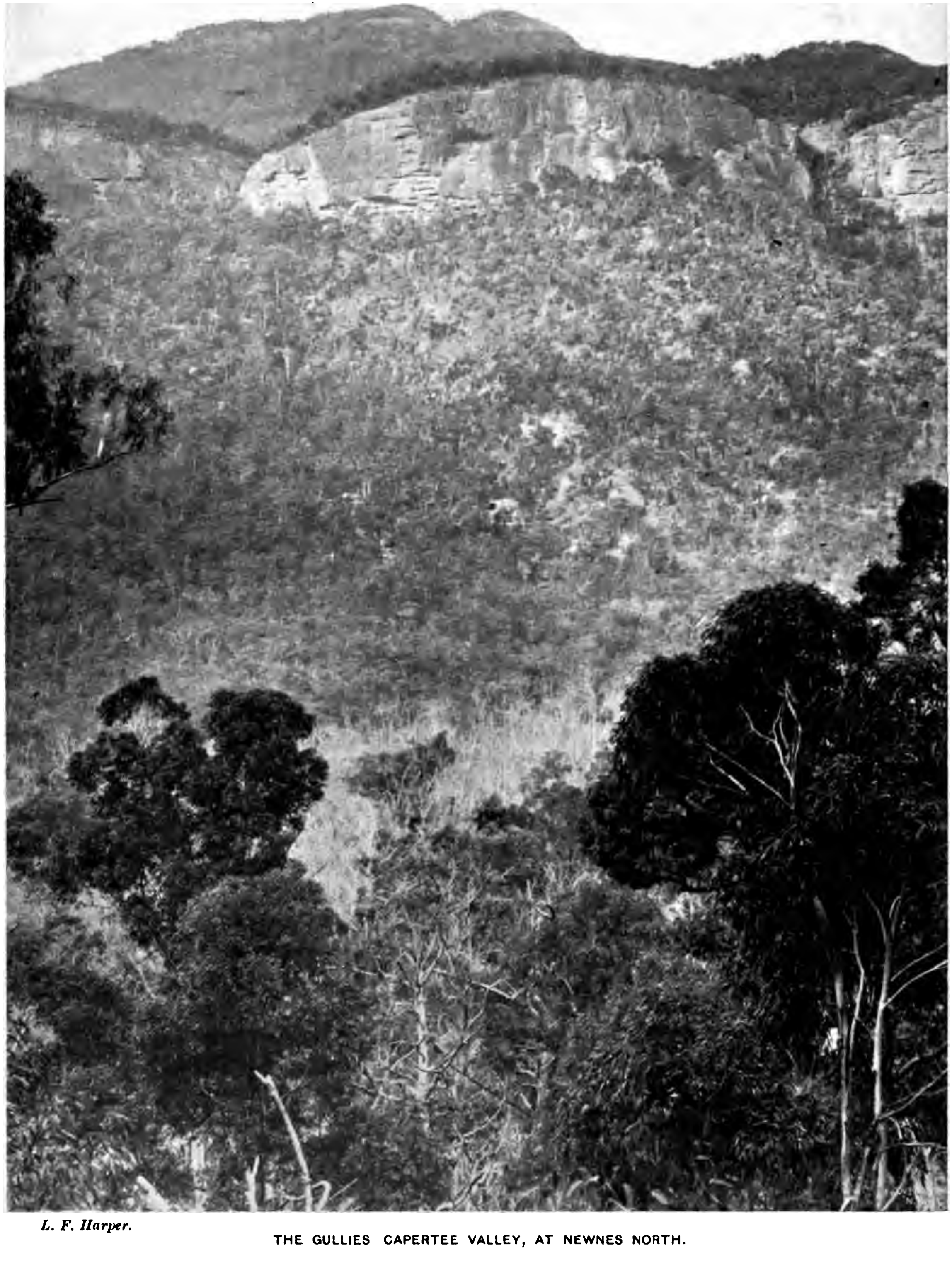
In the Newcastle section of the Upper Coal Measures, however, conglomerates are a predominant feature of the lower division. The Narrabeen stage of the overlying Hawkesbury series in this field is also distinguished from its southern and western extensions by conglomerate beds.

The Lithgow, Talbragar, and Gunnedah Coal Measures are persistently cherty in their upper divisions, and shaly and arenaceous below.

At Ballimore Hill, firing of the coal outcrops has converted some of the cherty shales into porcellanite, and has imparted finely prismatic structure to ironstone bands.

In the later stage of the Permo-Carboniferous, volcanic activity, in as yet undiscovered centres, spread vast quantities of fine felsitic dust over the marshy areas in which the coal plants flourished, which afterwards became compacted into fine cherts.

PLAT. XVII.



L. F. Harper.

THE GULLIES CAPERTEE VALLEY, AT NEWNES NORTH.

The "Lithgow" seam thins rapidly to south and south-west on the rise from the Lithgow workings, but maintains greater marginal strength as the Coal Measures bend to the west in the Upper Burragorang or Wollondilly Valley.

At Colong Gap, close to the Peaks Silver Mines, a tunnel has been driven for some distance into this seam, which here occurs in small outliers of Coal Measures, capping bold cliff escarpments of Upper Marine age (The Peaks), which at a distance simulate Hawkesbury Sandstone. At the summit of the cliffs the characteristic Marangaroo conglomerate is conspicuously developed.

Slade's Tunnel starts from the bridle-track over Colong Gap, between The Peaks and Myanga Valley. The coal-seam is somewhat crumbly in its upper portion, though its constitution has evidently not been seriously affected by weathering. Its thickness and quality are revealed in the following section and analysis :—

	ft.	in.	
Sandstone roof.			
Shale band	0	3	
Bituminous coal ...	0	5	Sample, exclusive of bands.
Shale band	0	0½	
Bituminous coal ...	2	2	
Shale band	0	0¼	
Bituminous coal ...	0	10	
Shale band	0	2	
Stony coal	0	11	
Shale band	0	0¼	
Splint coal	0	1½	
Shale band	0	1 to 1½	
Splint coal	0	5	

Proximate Analysis.—W. A. Greig.—No. 4,516.

Sample, exclusive of bands.	
Hygroscopic moisture ...	11·22
Volatile hydrocarbons ...	26·93
Fixed carbon	51·42
Ash	10·42
	100·00

No true coke formed.
Ash—nearly white, granular.
Specific gravity, 1·485.
Sulphur in coal, 0·384 per cent.

In the Megalong Valley, the Writer measured a section of the Coal Measures at Mort's Shale Mine,[1] totalling one hundred and eighty-eight feet, not including the Marangaroo conglomerate. Further south, Professor David measured another equalling one hundred and ninety-seven feet.[2]

---

[1] Kerosene Shale Deposits, Mem. Geol. Survey N. S. Wales, Geol. 3, 1903, p. 205.
[2] Ann. Rept. Dept. Mines for 1890, p. 222.

In Portion 21, Parish Kadumba, County Cook, under the Western Cliffs of King's Tableland, the following section of the "Lithgow" seam was measured :—

	ft.	in.		*Analysis by W. A. Greig.*	
Sandstone roof.					
Coal	1	6	No. 2647. Exclusive of band.	Hygroscopic moisture	1·70
Clay shale	0	2		Volatile hydrocarbons	27·48
Coal	1	1½		Fixed carbon	58·40
Clay shale	2	0		Ash	12·22

Coke—Fairly well swollen, firm, and lustrous.
Ash—Grey, flocculent.
Sulphur in coal, 0·508 per cent.
Specific gravity, 1·369 „
Calorific power, 11·5 lb.

INCEPTION OF THE WESTERN COAL INDUSTRY.

Coal was probably first won in the Western Coal-field by Mr. Andrew Brown, of Bowenfels, in connection with his Coerwull flour-mill erected in 1848, or the substituted woollen industry of 1858, which still continues.

The construction of the Great Western Railway extension from Mount Victoria into the Lithgow Valley by the great Zig Zag, doubtless first directed attention to the potentialities of the coal-seam outcropping in the Valley, for Mr. H. Winchester, of the Coal-fields Office, Newcastle, states that Messrs. Woolley and Anderson, storekeepers, of Main Camp, No. 5 section, Bowenfels, employed men to get coal for the railway contractor, Mr. P. Higgins.

Mr. J. J. Poole, Managing Director, Centenary Colliery, Curlewis, states that tunnelling with a view to commercial coal mining—*i.e.*, for export from the Valley—was inaugurated by him in 1868 on the Hermitage Estate of the Rev. Colin Stewart, and that Mr. Thomas Brown followed shortly afterwards on similar lines at Eskbank.

The Hermitage Estate embraces Portion 1A, of one hundred and thirty acres, Parish Marangaroo, County Cook, alienated to the Rev. C. Stewart by Crown Grant, dated 5th September, 1868, now comprising part of the colliery of that name.

The output for 1874 is given in "Mines and Mineral Statistics of New South Wales," prepared for New South Wales Intercolonial and Philadelphia Exhibition, 1875, p. 58.

Lithgow Valley Colliery	18,000	tons.
Thomas Brown, Esq., M.L.A., Esk Creek Colliery	8,600	,,
Bowenfels Colliery Company	8,500	,,
Vale of Clwydd Company	50	,,
Bulkeley's Coal Mine, Blackman's Flat, Mudgee Road ...	50	,,
	35,200	,,

The Department of Mines was inaugurated in 1874, its first report being that for 1875.

TOTAL recorded output of Western Coal-field to the end of 1906.

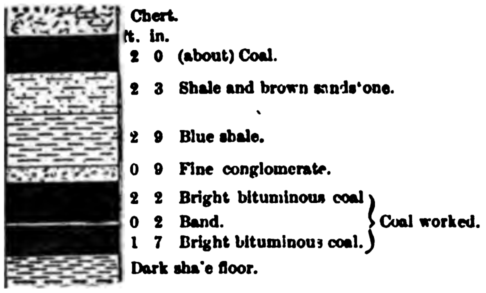
Colliery.	Locality.	Period.	Output.	Remarks.
			Tons.	
*Eskbank	Lithgow Valley	1869-1903	1,503,944	Closed. Part worked in connection with Iron Works.
Hermitage	,,	1869-1906	650,406	
Lithgow Valley	,,	1874-1906	1,588,456	
Vale of Clwydd	,,	1874-1906	1,291,230	
*Iron Works	,,	1881-1906	149,309	Part of Old Eskbank Colliery.
Zig Zag	,,	1883-1906	1,022,469	
Oakey Park	,,	1888-1906	733,502	
Vale	,,	1888-1900	449,761	Closed in 1900.
Great Cobar (Limited)	,,	1899-1906	224,329	Worked in connection with Copper smelting only.
Cooerwull	Bowenfels	1870-1906	30,996	Worked principally in connection with Woollen Mills.
Bowenfels	,,	1874-1883	67,229	Now part of Hermitage Colliery.
Methven	,,	1904-1906	858	
South Bowenfels	,,	1897-1903	1,216	
Bulkeley's	Blackman's Flat	1874-1876	....	Closed.
Folly	Lidsdale	1888-1906	6,243	Rarely worked.
Commonwealth	,,	1895-1906		
Black Diamond	Blackman's Flat	1895-1902	5,995	Closed.
Cullen Bullen	Cullen Bullen	1888-1900	203,217	Closed.
Invincible	,,	1905-1906	12,698	
Irondale	Piper's Flat	1883-1906	190,078	
Ivanhoe	,,	1893-1906	192,144	Worked in connection with Commonwealth Portland Cement Works.
Portland	near Portland	1905-1906	1,249	
Piper's Flat	,,	1903	22	Closed.
Great Western	near Cullen Railway Station.	1904	98	Closed.
Retorts and Main Camp	Hartley Vale	1883-1906	170,132	Exclusive of early coal consumption at shale retorts.
North's	Katoomba	1882-1904	379,178	Not continuously worked.
Torbane	Airly-Torbane	1900-1906	15,150	Worked in connection with shale retorts.
Rawdon	Cox's Siding	1887-1895	16,052	Closed.
Carlo's Gap	near Carwell	1884-1903	1,946	Closed.
			8,967,927	Probably at least 9,000,000 tons.

---

* The Eskbank and Iron Works are identical. The former was purchased and closed by the Associated Collieries, the Iron Works roprietary, however, continuing to work for its own use only.

Wallace's Black Diamond Colliery, worked in 1896; closed in July, 1902. Output, 5,995 tons.

FIG. 38.—(Section by J. Mackenzie.)[1]



Analysis of Black Diamond Coal.[2]

Hygroscopic moisture	1·85
Volatile hydrocarbons	33·55
Fixed carbon	46·65
Ash	17·95
	100·00
Sulphur	0·658
Specific gravity	1·458
Coke	64·60 per cent.

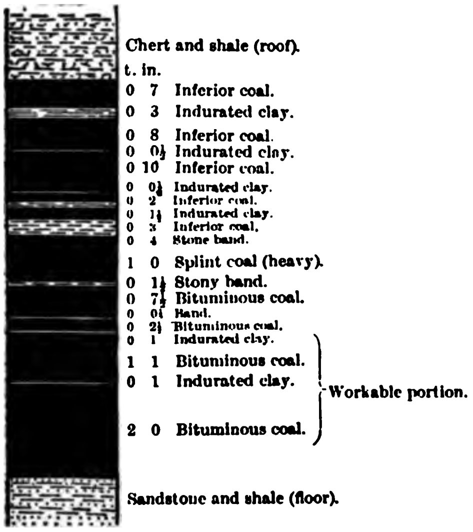
Calorific power—1 lb. of coal will convert 11·0 lb. of water into steam.

Coke—not much swollen, fairly bright, firm, covered with cauliflower-like excrescences.

Ash—white, granular.

"Upper Irondale" seam, exposed in tunnel sixty feet above the Cullen Bullen working seam (the "Lithgow"). After Mackenzie.[3]

FIG. 39.



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[1] Ann. Rept. Dept. Mines for 1895, p. 102.
[2] Mineral Resources N. S. Wales, 1901, p. 344.
[3] Ann. Rept. Dept. Mines for 1889, p. 189.

North and east in the Capertee and Grose Valleys, a thin coal-seam, eight to fourteen inches in thickness, appears below the Marangaroo, whilst the Lithgow Seam above it diminishes to an equal thinness.

From these points on strike and dip, no outcrops are visible for many miles, owing to the inclination of the strata exceeding the fall of the drainage. At Gunnedah, however, about one hundred and fifty miles northerly, the main working seam in the Black Jack and Curlewis Collieries occurs about thirty feet below a well-developed quartz-pebble conglomerate, remarkably like the Marangaroo. If it corresponds, then the seam immediately above it in the Lithgow Coal-field has disappeared at Gunnedah, whilst the underlying thin seam of Grose and Capertee Valleys has developed northerly into the excellent six-foot seam of Gunnedah and Curlewis. Detail survey of the latter field, however, is necessary to establish exact relationship.

The Marangaroo is the only conspicuous and persistent conglomerate bed in the marginal area of the Upper Coal Measures in the Western Coal-field, and, as before stated, occurs at their base.

In the roof of the Lithgow Seam, immediately in contact with the coal, pebbles are frequent in the sandstone. In places, as at Blackman's and Piper's Flats, near Wallerawang, the roof becomes wholly conglomeratic for short distances.

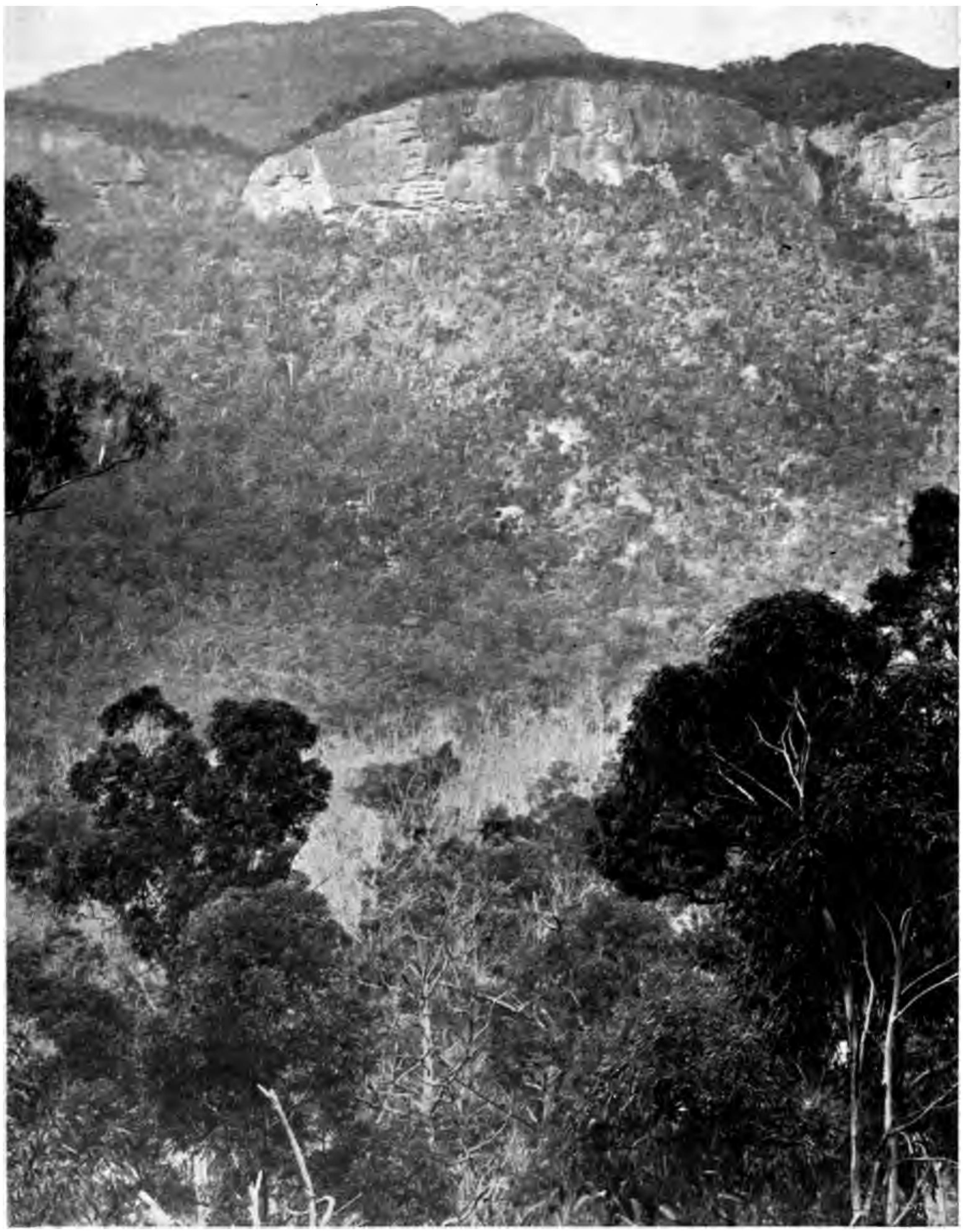
In the Newcastle section of the Upper Coal Measures, however, conglomerates are a predominant feature of the lower division. The Narrabeen stage of the overlying Hawkesbury series in this field is also distinguished from its southern and western extensions by conglomerate beds.

The Lithgow, Talbragar, and Gunnedah Coal Measures are persistently cherty in their upper divisions, and shaly and arenaceous below.

At Ballimore Hill, firing of the coal outcrops has converted some of the cherty shales into porcellanite, and has imparted finely prismatic structure to ironstone bands.

In the later stage of the Permo-Carboniferous, volcanic activity, in as yet undiscovered centres, spread vast quantities of fine felsitic dust over the marshy areas in which the coal plants flourished, which afterwards became compacted into fine cherts.

PLAT XVII.



L. F. Harper.

THE GULLIES CAPERTEE VALLEY, AT NEWNES NORTH.

The "Lithgow" seam thins rapidly to south and south-west on the rise from the Lithgow workings, but maintains greater marginal strength as the Coal Measures bend to the west in the Upper Burragorang or Wollondilly Valley.

At Colong Gap, close to the Peaks Silver Mines, a tunnel has been driven for some distance into this seam, which here occurs in small outliers of Coal Measures, capping bold cliff escarpments of Upper Marine age (The Peaks), which at a distance simulate Hawkesbury Sandstone. At the summit of the cliffs the characteristic Marangaroo conglomerate is conspicuously developed.

Slade's Tunnel starts from the bridle-track over Colong Gap, between The Peaks and Myanga Valley. The coal-seam is somewhat crumbly in its upper portion, though its constitution has evidently not been seriously affected by weathering. Its thickness and quality are revealed in the following section and analysis :—

	ft.	in.
Sandstone roof.		
Shale band	0	3
Bituminous coal ...	0	5
Shale band	0	0½
Bituminous coal ...	2	2
Shale band	0	0¼
Bituminous coal ..	0	10
Shale band	0	2
Stony coal	0	11
Shale band	0	0¼
Splint coal	0	1½
Shale band	0	1 to 1½
Splint coal	0	5

Proximate Analysis.—W. A. Greig.—No. 4,516.

Sample, exclusive of bands.	Hygroscopic moisture ...	11·22
	Volatile hydrocarbons ...	26·93
	Fixed carbon	51·42
	Ash	10·42
		100·00

No true coke formed.
Ash—nearly white, granular.
Specific gravity, 1·485.
Sulphur in coal, 0·384 per cent.

In the Megalong Valley, the Writer measured a section of the Coal Measures at Mort's Shale Mine,[1] totalling one hundred and eighty-eight feet, not including the Marangaroo conglomerate. Further south, Professor David measured another equalling one hundred and ninety-seven feet.[2]

---

[1] Kerosene Shale Deposits, Mem. Geol. Survey N. S. Wales, Geol. 3, 1903, p. 205.

[2] Ann. Rept. Dept. Mines for 1890, p. 222.

In the first-mentioned, the "Lithgow" seam horizon is erroneously recorded below the Marangaroo. It corresponds with the split coal-seam just above it, of which the following is a section :—

	ft.	in.
Sandstone and clay shale roof.		
Bituminous coal	0	7
Clay shale	2	0
Kerosene shale	0	8
Semi-bituminous coal...	3	4
Sandstone	2	0
Coal	1	0
Clay shale (floor).		

In its southern extension from this point it shows considerable improvement, as Professor David's section reveals :—[1]

ft.	in.	
		Roof, black shale.
0	10	... Coal, bituminous and splint, good.
0	0¼	... Band, white clay.
0	5¾	... Coal, splint, good.
0	2½	... Band, hard, dark sandy shale.
0	3¼	... Coal, splint.
0	0¾	... Band, brown and white clay.
0	6	... Coal, splint, good.
0	0½	... Parting, soft, dull, dirty coal.
1	1	... Coal, splint, good.
0	10½	... Coal, good splint, inclined to cannel, small conchoidal fracture.
0	4½	... Coal, soft bituminous.
0	5	... Coal, good splint,
1	5	... Coal, bituminous, with a little splint, rather soft and brittle.
0	5	... Coal, soft, and a trifle dirty.

An average sample of the good splint coal yielded the following results :—

No. 156.—*Proximate Analysis.*—J. C. H. Mingaye.

Hygroscopic moisture	2·619
Volatile hydrocarbons	25·831
Fixed carbon	59·600
Ash	11·950
	100·00

Sulphur in coal, ·658 per cent.
Specific gravity, 1·389
No-true coke formed. Ash—colour, grey.

Of the seven feet thickness, Professor David estimated that five feet should be workable.[1]

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[1] Ann. Rept. Dept. Mines for 1890, p. 222.

In Portion 21, Parish Kadumba, County Cook, under the Western Cliffs of King's Tableland, the following section of the "Lithgow" seam was measured :—

	ft.	in.		*Analysis by W. A. Greig.*	
Sandstone roof.					
Coal	1	6	No. 2647. Exclusive of band.	Hygroscopic moisture	1·70
Clay shale	0	2		Volatile hydrocarbons	27·48
Coal	1	1½		Fixed carbon	58·40
Clay shale	2	0		Ash	12·22

Coke—Fairly well swollen, firm, and lustrous.
Ash—Grey, flocculent.
Sulphur in coal, 0·508 per cent.
Specific gravity, 1·369 ,,
Calorific power, 11·5 lb.

INCEPTION OF THE WESTERN COAL INDUSTRY.

Coal was probably first won in the Western Coal-field by Mr. Andrew Brown, of Bowenfels, in connection with his Coerwull flour-mill erected in 1848, or the substituted woollen industry of 1858, which still continues.

The construction of the Great Western Railway extension from Mount Victoria into the Lithgow Valley by the great Zig Zag, doubtless first directed attention to the potentialities of the coal-seam outcropping in the Valley, for Mr. H. Winchester, of the Coal-fields Office, Newcastle, states that Messrs. Woolley and Anderson, storekeepers, of Main Camp, No. 5 section, Bowenfels, employed men to get coal for the railway contractor, Mr. P. Higgins.

Mr. J. J. Poole, Managing Director, Centenary Colliery, Curlewis, states that tunnelling with a view to commercial coal mining—*i.e.*, for export from the Valley—was inaugurated by him in 1868 on the Hermitage Estate of the Rev. Colin Stewart, and that Mr. Thomas Brown followed shortly afterwards on similar lines at Eskbank.

The Hermitage Estate embraces Portion 1A, of one hundred and thirty acres, Parish Marangaroo, County Cook, alienated to the Rev. C. Stewart by Crown Grant, dated 5th September, 1868, now comprising part of the colliery of that name.

The output for 1874 is given in "Mines and Mineral Statistics of New South Wales," prepared for New South Wales Intercolonial and Philadelphia Exhibition, 1875, p. 58.

Lithgow Valley Colliery	18,000 tons.
Thomas Brown, Esq., M.L.A., Esk Creek Colliery	8,600 „
Bowenfels Colliery Company	8,500 „
Vale of Clwydd Company	50 „
Bulkeley's Coal Mine, Blackman's Flat, Mudgee Road ...	50 „
	35,200 „

The Department of Mines was inaugurated in 1874, its first report being that for 1875.

TOTAL recorded output of Western Coal-field to the end of 1906.

Colliery.	Locality.	Period.	Output.	Remarks.
			Tons.	
*Eskbank	Lithgow Valley	1869-1903	1,503,944	Closed. Part worked in connection with Iron Works.
Hermitage	„	1869-1906	650,406	
Lithgow Valley	„	1874-1906	1,588,456	
Vale of Clwydd	„	1874-1906	1,291,230	
*Iron Works	„	1881-1906	149,309	Part of Old Eskbank Colliery.
Zig Zag	„	1883-1906	1,022,469	
Oakey Park	„	1888-1906	733,502	
Vale	„	1888-1900	449,761	Closed in 1900.
Great Cobar (Limited)	„	1899-1906	224,329	Worked in connection with Copper smelting only.
Cooerwull	Bowenfels	1870-1906	30,996	Worked principally in connection with Woollen Mills.
Bowenfels	„	1874-1883	67,229	Now part of Hermitage Colliery.
Methven	„	1904-1906	858	
South Bowenfels	„	1897-1903	1,216	
Bulkeley's	Blackman's Flat	1874-1876	....	Closed.
Folly	Lidsdale	1888-1906	6,243	Rarely worked.
Commonwealth	„	1895-1906		
Black Diamond	Blackman's Flat	1895-1902	5,995	Closed.
Cullen Bullen	Cullen Bullen	1888-1900	203,217	Closed.
Invincible	„	1905-1906	12,698	
Irondale	Piper's Flat	1883-1906	190,078	
Ivanhoe	„	1893-1906	192,144	Worked in connection with Commonwealth Portland Cement Works.
Portland	near Portland	1905-1906	1,249	
Piper's Flat	„	1903	22	Closed.
Great Western	near Cullen Railway Station.	1904	98	Closed.
Retorts and Main Camp	Hartley Vale	1883-1906	170,132	Exclusive of early coal consumption at shale retorts.
North's	Katoomba	1882-1904	379,178	Not continuously worked.
Torbane	Airly-Torbane	1900-1906	15,150	Worked in connection with shale retorts.
Rawdon	Cox's Siding	1887-1895	16,052	Closed.
Carlo's Gap	near Carwell	1884-1903	1,946	Closed.
			8,967,927	Probably at least 9,000,000 tons.

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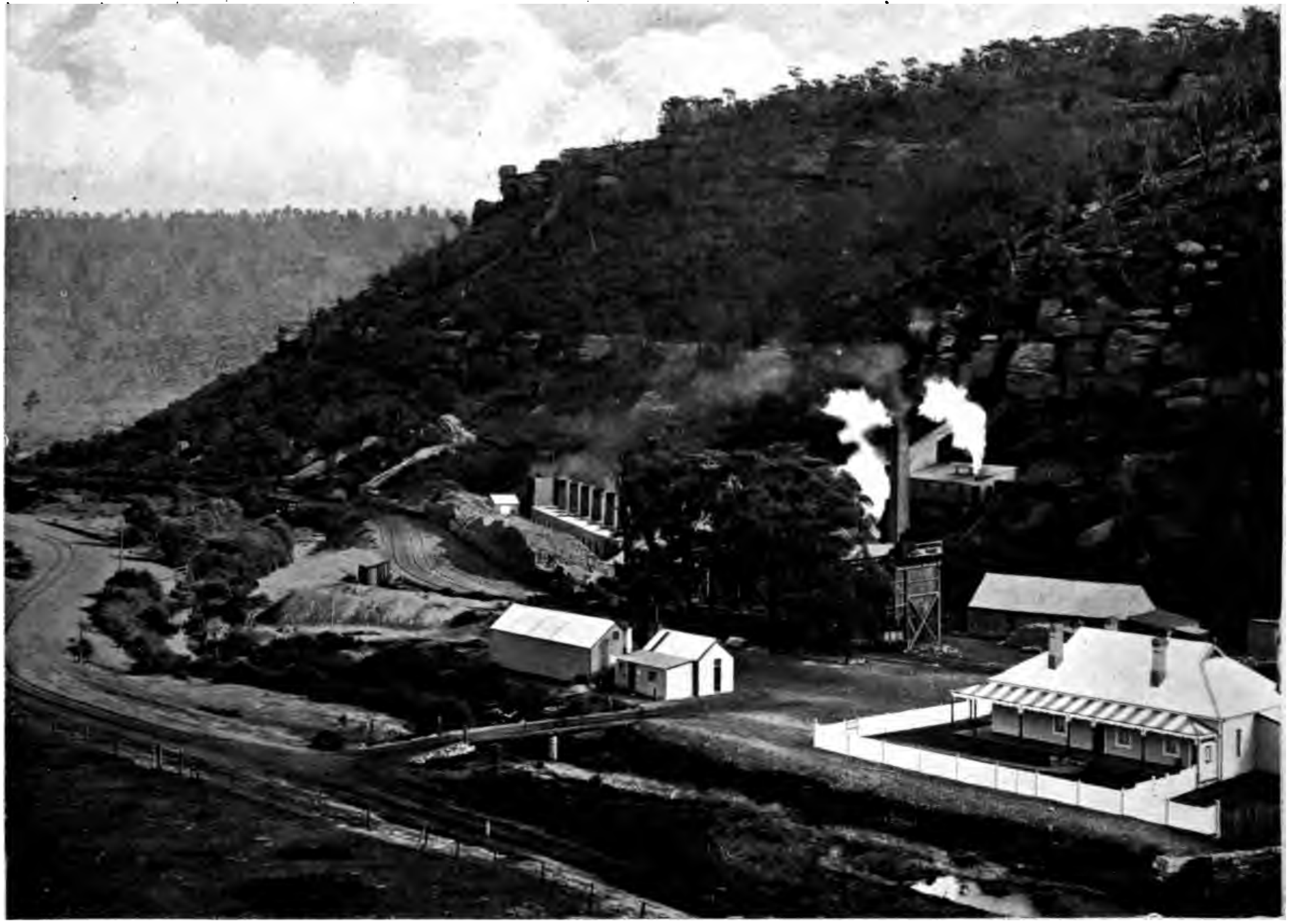
* The Eskbank and Iron Works are identical. The former was purchased and closed by the Associated Collieries, the Iron Works roprietary, however, continuing to work for its own use only.



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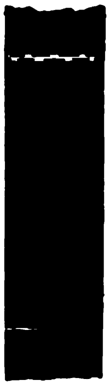
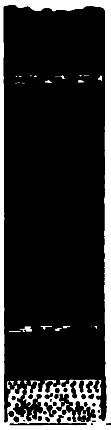
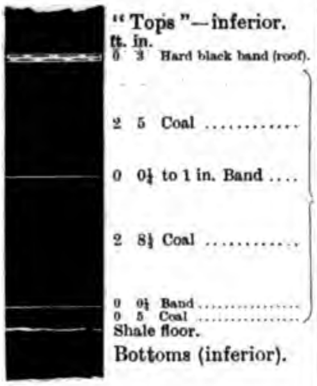
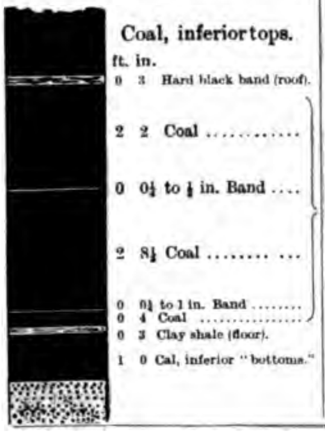
OAKEY PARK COLLIERY AND BEEHIVE COKE CVENS. LITHGOW VALLEY.

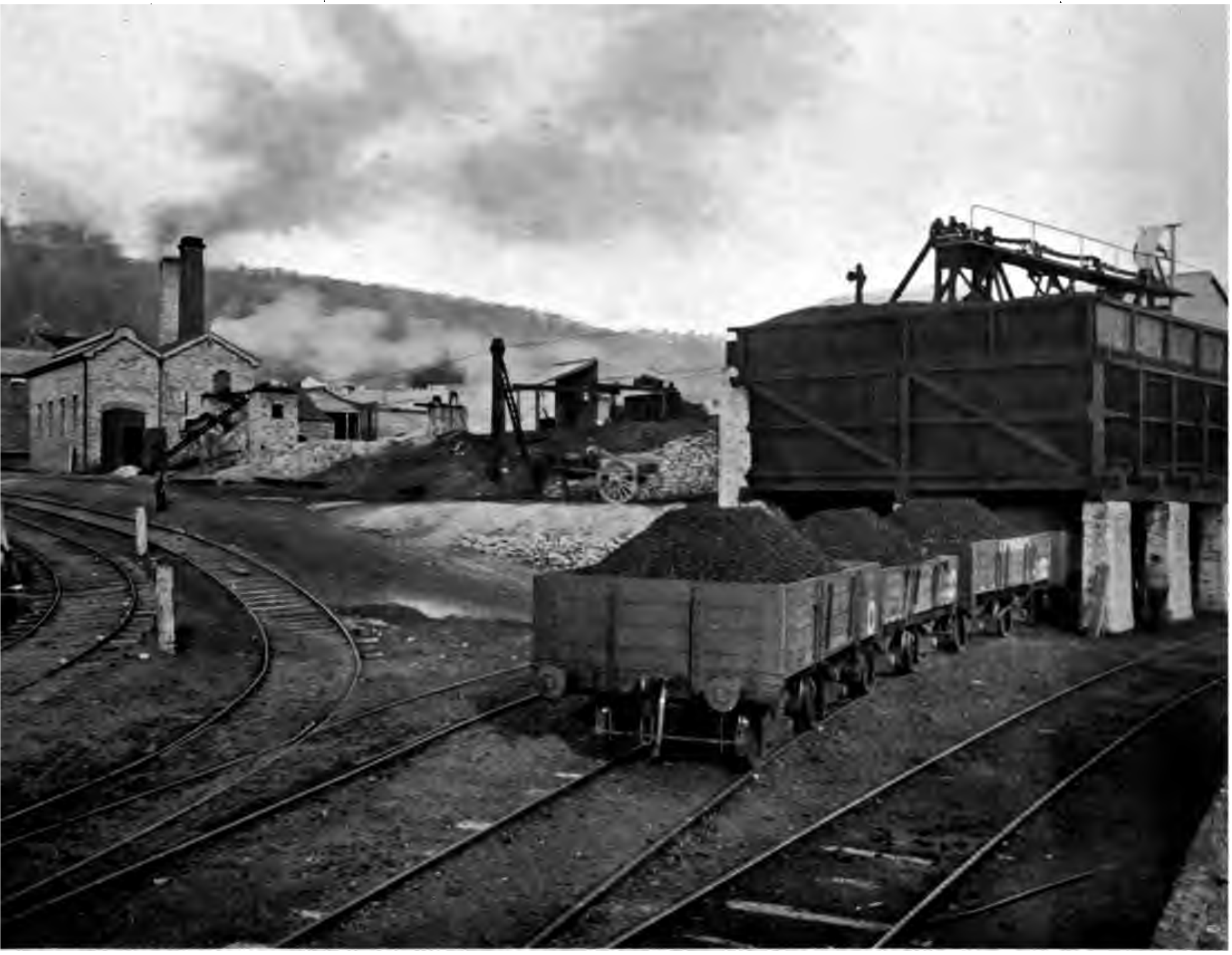
OAKEY PARK COLLIERY—*continued.*

	Hygroscopic Moisture.	Volatile Hydro-carbons.	Fixed Carbon.	Ash.	Sulphur.	Coke.	Specific Gravity.	Lbs. of water converted into steam by 1 lb. of this coal.	Remarks.	Analyst.	1906.–No. of Analysis.
FIG. 43.—No. 3 District West, Oakey Park Colliery.  "Tops"—inferior. ft. in. 0 3 Hard black band (roof).	...	...	...	...	...	...	...	...	5 ft. 1½ in. of coal worked, exclusive of bands.		
2 5 Coal .... 0 0½ to 1 in. Band .... 2 8½ Coal .... 0 0½ Band .... 0 5 Coal .... Shale floor. Bottoms (inferior).	1·73	32·72	54·75	10·80	0·590	65·55	1·363	12·5	Coke—Fairly swollen, fairly firm, lustrous. Ash—Grey in colour; semi-granular.	W. A. Greig.	5038
No. 1 East District, Oakey Park Colliery.  Coal, inferior tops. ft. in. 0 3 Hard black band (roof).	...	...	...	..	...	...	...	...	5 ft. 2½ in. of coal worked, exclusive of bands.		
2 2 Coal .... 0 0½ to ½ in. Band .... 2 8½ Coal .... 0 0½ to 1 in. Band .... 0 4 Coal .... 0 3 Clay shale (floor). 1 0 Cal, inferior "bottoms."	2·05	32·95	54·02	10·93	0·713	65 00	1·386	12·2	Coke—Fairly swollen; firm, and lustrous. Ash—Light grey in colour; semi-granular.	W. A. Greig.	5039

OAKEY PARK COLLIERY—*continued.*

	Hygroscopic Moisture.	Volatile Hydro-carbons.	Fixed Carbon.	Ash.	Sulphur.	Coke.	Specific Gravity.	Lbs. of water converted into steam by 1 lb. of this coal.	Remarks.	Analyst.	1906.—No. of Analysis.
FIG. 43.—No. 3 District West, Oakey Park Colliery.  “Tops”—inferior. ft. in. 0 3 Hard black band (roof). 2 5 Coal .... 0 0¼ to 1 in. Band .... 2 8½ Coal .... 0 0½ Band .... 0 5 Coal .... Shale floor. Bottoms (inferior).	...	...	...	...	...	...	...	...	5 ft. 1½ in. of coal worked, exclusive of bands.		
	1·73	32·72	54·75	10·80	0·590	65·55	1·363	12·5	Coke—Fairly swollen, fairly firm, lustrous. Ash—Grey in colour; semi-granular.	W. A. Greig.	5038
No. 1 East District, Oakey Park Colliery.  Coal, inferior tops. ft. in. 0 3 Hard black band (roof). 2 2 Coal .... 0 0¼ to ½ in. Band .... 2 8½ Coal .... 0 0½ to 1 in. Band .... 0 4 Coal .... 0 3 Clay shale (floor). 1 0 Cal, inferior “bottoms.”	...	...	...	...	...	...	...	...	5 ft. 2½ in. of coal worked, exclusive of bands.		
	2·05	32·95	54·02	10·98	0·713	65 00	1·386	12·2	Coke—Fairly swollen; firm, and lustrous. Ash—Light grey in colour; semi-granular.	W. A. Greig.	5039

PLATE



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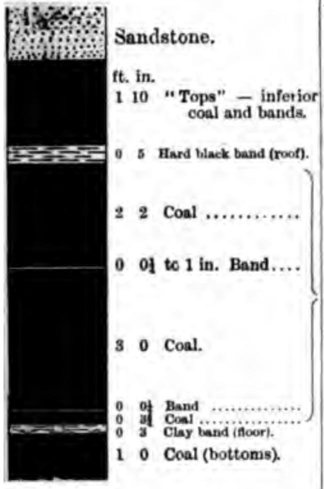
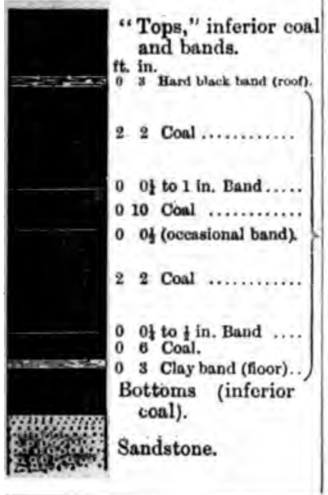
LITHGOW VALLEY COLLIERY

LITHGOW VALLEY COLLIERY.—18 on Map of Western Coal-field. Opened in the "Lithgow" seam by tunnel, in 1869. Method of work—bord and pillar. Furnace ventilation. Electric pumping and lighting. Lower part of seam worked. Endless rope haulage. Contract winning. Official output to end of 1906, 1,588,456 tons.

Fig. 44.—Dip Heading, Lithgow Valley Colliery.	Hygroscopic Moisture.	Volatile Hydro-carbons.	Fixed Carbon.	Ash.	Sulphur.	Coke.	Specific Gravity.	Lbs. of water converted into steam by 1 lb. of this coal.	Remarks.	Analyst.	1906—No. of Analysis.
 Sandstone. ft. in. 1 10 "Tops"—inferior coal and bands. 0 5 Hard black band (roof). 2 2 Coal 0 0¼ to 1 in. Band 3 0 Coal. 0 0¼ Band 0 3¾ Coal 0 3 Clay band (floor). 1 0 Coal (bottoms).	...	...	...	...	...	...	...	...	5 ft. 5¾ in. of coal worked, exclusive of bands.		
	1·88	31·74	53·75	12·63	0·603	66·38	1·338	12·0	Coke—Slightly swollen, firm, fairly lustrous.	W. A. Greig	5040
Fig. 45.—Far End Rise, Lithgow Valley Colliery.  "Tops," inferior coal and bands. ft. in. 0 3 Hard black band (roof). 2 2 Coal 0 0¼ to 1 in. Band 0 10 Coal 0 0½ (occasional band). 2 2 Coal 0 0¼ to ½ in. Band 0 6 Coal. 0 3 Clay band (floor).. Bottoms (inferior coal). Sandstone.	...	...	...	...	...	...	...	...	5 ft. 8 in. of coal worked, exclusive of bands.		
	1·66	32·60	54 85	10·89	0 631	65·74	1·324	12·4	Coke—Slightly swollen, firm, fair lustre. Ash—Light grey in colour; semi-granular.	W. A. Greig	5041

HERMITAGE COLLIERY.—12 on Map of Western Coal-field. Opened in "Lithgow" coal-seam in 1869 by tunnel. Method of work—bord and pillar. Furnace ventilation. Compressed air pumping. Endless rope haulage. Contract winning. Official output to end of 1906, 650,406 tons. Lower part of seam worked.

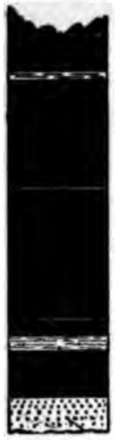
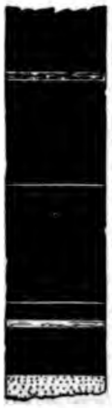
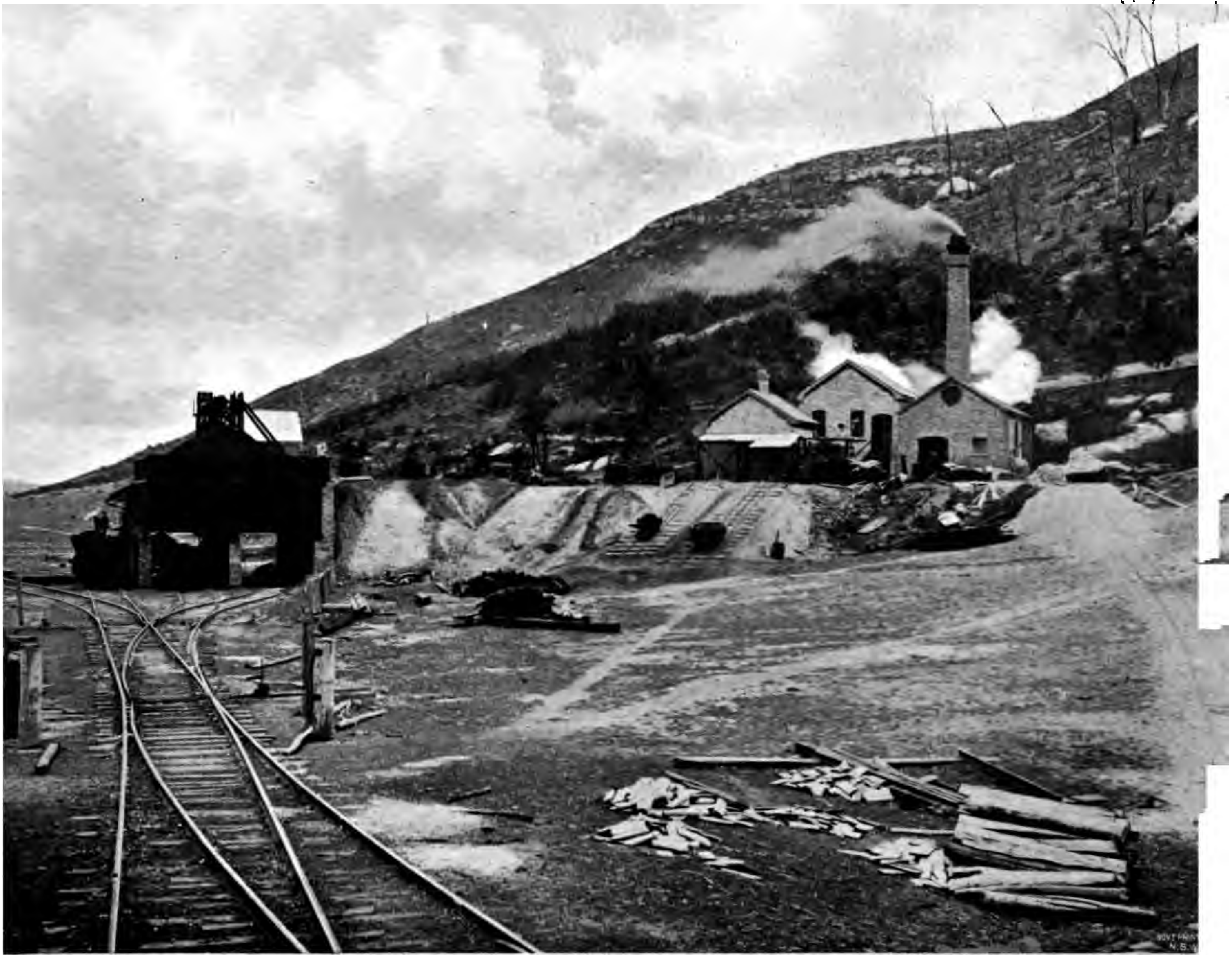
	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Coke.	Specific Gravity.	Lbs. of water converted into steam by 1 lb. of this coal.	Remarks.	Analyst.	1906—No. of Analysis.
Fig. 46.—North Main Heading, Hermitage Colliery.  Coal (inferior tops up to 5 ft. thick). ft. in. 0 3 Hard black band (roof). 2 2 Coal .... 0 0¼ to ½ in. Band .... 2 6¼ Coal .... 0 0¼ Band .... 0 4 Coal .... 0 3 Clay band (floor). 1 0 Inferior coal (bottoms).	...	...	...	...	...	...	...	...	5 ft. 0¼ in. of coal worked, exclusive of bands.		
	2·26	28·01	57·23	12·50	0·603	...	1·417	11·2	Formed a friable cake on heating, of a dull colour; not true coke. Ash — White; semi-granular.	W.A.Greig	5042
Fig. 47.—West Heading, Hermitage Colliery.  Coal (inferior tops up to 5 ft. thick). ft. in. 0 3 Black stony band (roof). 2 2 Coal .... 0 0¼ to ½ in. Band .... 2 5 Coal .... 0 0¼ to ½ in. Band .... 0 4 Coal .... 0 3 Clay band (floor). 1 0 Inferior coal (bottoms). Sandstone.	...	...	...	...	...	...	...	...	4 ft. 11 in. of coal worked, exclusive of bands.		
	2·55	26·93	57·03	13·49	0·645	...	1·412	11·0	No true coke formed. Ash—Grey in colour; semi-granular.	W.A.Greig	5043

PLATE XX.



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HERMITAGE COLLIERY LITHGOW VALLEY.

IRONDALE COLLIERY.—Lower Tunnel. Main Straight.

Section.		ft.	in.
Sandstone and conglomerate roof.			
Coal	... ...	0	8
Band	... ...	0	0½
Coal	... ...	2	0
Band	... ... ¼ in. to	0	1
Coal	... ...	0	1½
Band	... ...	0	1
Coal	... ...	1	1
Band	... ...	0	0¼
Coal	... ...	0	8½
Band	... ... 1½ in. to	0	2
Coal	... ...	1	9½.
		6	8

Floor—carbonaceous shale.

Proximate Analysis.—W. A. Greig.

No. 6442 (exclusive of bands).

Hygroscopic moisture...	... 3·60
Volatile hydrocarbons	... 27·10
Fixed carbon	... 56·41
Ash	... 12·89
	100·00

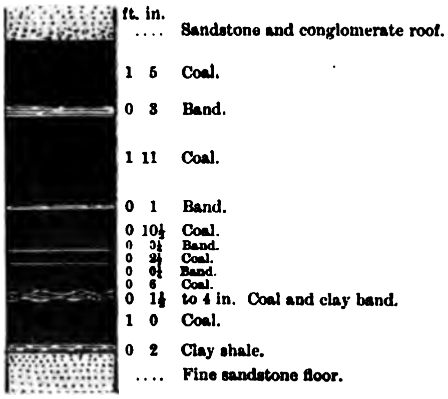
Sulphur in coal	... 0·466 per cent.
Specific gravity	... 1·405 „
Calorific power	... 11·0 „

Coke—Formed a compact brittle mass on heating in a closed crucible.

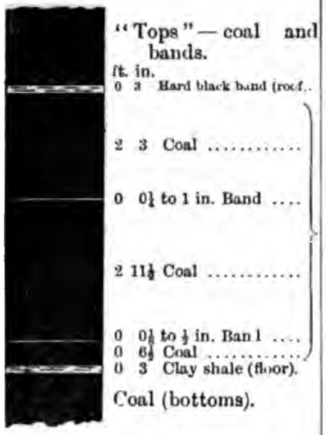
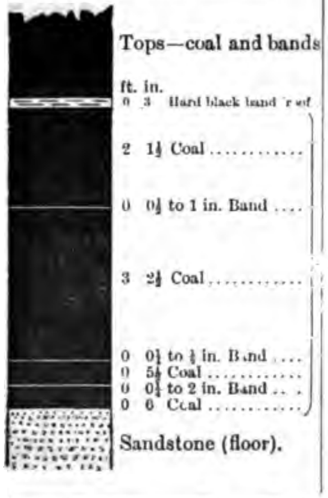
Ivanhoe Colliery, Piper's Flat, 16 on Plan of Western Coal-field. The property of the Commonwealth Portland Cement Company, Limited. Connected with the State railway and the cement works by standard gauge railway line. Situated about three thousand and ten feet above sea-level, in Portion 5, Parish Falnash, County Cook, five miles from Wallerawang, and one hundred and nine from Sydney. The bottom (Lithgow) seam is opened for about half a mile; the upper seam—sixty-two feet above—is not worked in this colliery.

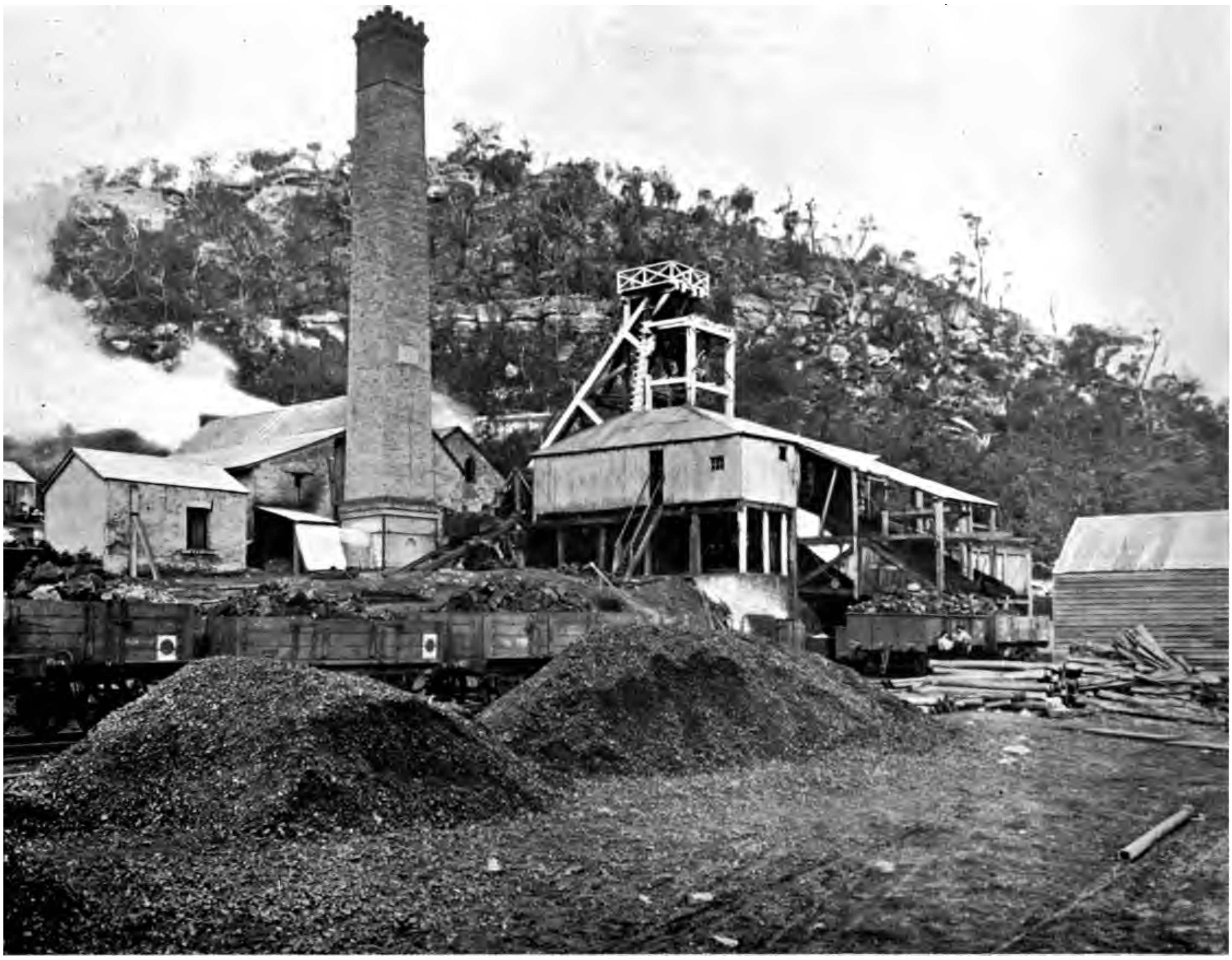
The following section was measured at the tunnel mouth:—

FIG. 55.



Zig Zag Colliery.—25 on Map of Western Coal-field. Opened in "Lithgow" seam by shaft 270 feet deep in 1882. Method of work—bord and pillar. Furnace ventilation. Electric lighting. Steam pumping. Main and tail rope haulage. Contract winning. Official output to end of 1906, 1,022,469 tons. Lower part of seam worked.

	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Coke.	Specific Gravity.	Lbs. of water converted into steam by 1 lb. of this coal.	Remarks.	Analyst.	1906—No. of Analysis.
Fig. 50.- Zig Zag Colliery. North boundary, No. 3 section.  "Tops"—coal and bands. ft. in. 0 3 Hard black band (roof). 2 3 Coal .... 0 0¼ to 1 in. Band .... 2 11½ Coal .... 0 0¼ to ½ in. Band .... 0 6½ Coal .... 0 3 Clay shale (floor). Coal (bottoms).	...	...	...	...	...	...	...	...	5 ft. 9 in. of coal worked, exclusive of bands.		
	1·28	32·94	54·07	11·71	0·686	65·78	1·330	12·1	Coke—Fairly swollen, firm, lustrous. Ash—White; semi-granular.	W.A.Greig	5047
Fig. 51.—Zig Zag Colliery. No. 1 Cross-cut Heading.  Tops—coal and bands ft. in. 0 3 Hard black band (roof) 2 1½ Coal .... 0 0½ to 1 in. Band .... 3 2½ Coal .... 0 0¼ to ½ in. Band .... 0 5½ Coal .... 0 0¼ to 2 in. Band .... 0 6 Coal .... Sandstone (floor).	...	...	...	...	...	...	..	...	6 ft. 3½ in. of coal worked, exclusive of bands.		
	1·50	32·99	54·10	11·50	·740	65·60	1·346	12·3	Coke—Fairly swollen, firm, lustrous. Ash—Grey in colour; semi-granular.	W.A.Greig	5048



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VALE OF CLWYDD COLLIERY, LITHGOW VALLEY.

The Vale Colliery, Lithgow Valley, was opened in 1888, and closed in 1900, after a production of 449,761 tons.

The "Lithgow" seam was here worked by shaft three hundred and thirty-three feet deep to floor of seam. The workable thickness of lower portion was about five feet six inches; but it is reported to have thinned out eastwards to unworkable dimensions.

South Bowenfels Colliery, 23 on Map of Western Coal-field, adjoining the Lithgow Valley Colliery on the west, is now only worked on a small scale.

The following section was measured at the tunnel entrance, under a solid roof of sandstone:—

		ft.	in.
Sandstone roof, with pebbles at base		6	0
Coal	1 ft. 3 in. to	1	5
Cherty band	3 in. to	0	6
Coal	1 ft. 2½ in. to	1	4
Band		0	1
Coal		0	9
Coal, with three bands		0	2½
Coal		0	7
Coal and bands	½ in. to	0	2
Coal		2	2
Band	½ in. to	0	1
Coal		1	0
Floor not seen.			
		7	2½

The Methven Colliery, 19 on Map of Western Coal-field, adjoining the Hermitage on the west, is the most recently opened, and is also intermittently worked to a slight extent.

The following section was measured at the tunnel entrance:—

		ft.	in.
Banded sandstone and sandy shales.			
Sandstone		3	6
Carbonaceous shales—pinching out in places		1	0
Sandstone, with pebbles at base (roof)		4	7
Coal		0	6
Band	½ in. to	0	1
Coal		0	8
Band		0	1
Coal		1	0
Band	½ in. to	0	1
Coal		2	4½
Band	½ in. to	0	1
Coal		0	4
Band		0	0¼
Coal		0	5
Carbonaceous shales passing down into ordinary clay shales (floor).			
		5	6½

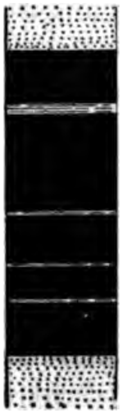
Irondale Colliery, Piper's Flat, Parish Cox, County Cook. On the Mudgee Railway, four miles from Wallerawang; and one hundred and eight miles from the Metropolis. Elevation, about three thousand one hundred and thirty feet above sea-level. No. 11 on Map of Western Coal-field.

Three seams exposed, two of which are worked (for section of Upper Seam, see page 182).

Colliery opened in 1883. Worked intermittently. Output to end of 1906 = 190,078 tons.

The Lower or "Lithgow" coal-seam (b) at Irondale exhibited the following section at the working face, about thirty chains from the tunnel mouth; and from it an average sample was carefully taken of the full thickness, exclusive of bands, which yielded the results on analysis.

FIG. 54.



ft.	in.	
....		Sandstone roof.
1	1	Coal.
0	2½	to 3 in. Band.
2	1½	Coal.
0	1	to 1½ in. Band.
1	0	Coal.
0	0½	to 1 in. Band.
0	8	Coal.
0	0½	Band.
1	1½	Coal.
6	5½	
....		Sandstone floor.

Proximate Analysis.—W. A. Greig.

No. 4251.

Hygroscopic moisture	3·84
Volatile hydrocarbons	25·75
Fixed carbon	55·08
Ash	15·33
	100·00

Coke No true coke. Slightly caked on coking.
Sulphur .... 0·466 per cent.
Specific gravity ...... 1·398 ,,
Calorific power 1 lb. of this coal will convert 11·2 lb. of water into steam.

IRONDALE COLLIERY.—Lower Tunnel. No. 1 Left District.

Section.		ft.	in.
Sandstone and conglomerate roof.			
Coal	... ...	1	10
Band	... ...	0	2
Coal	... ...	2	1
Band	... ... 1 in. to	0	1½
Coal	... ...	1	10
Band	... ...	0	3
Coal	... ...	1	2
		7	4¾

Proximate Analysis.—W. A. Greig.

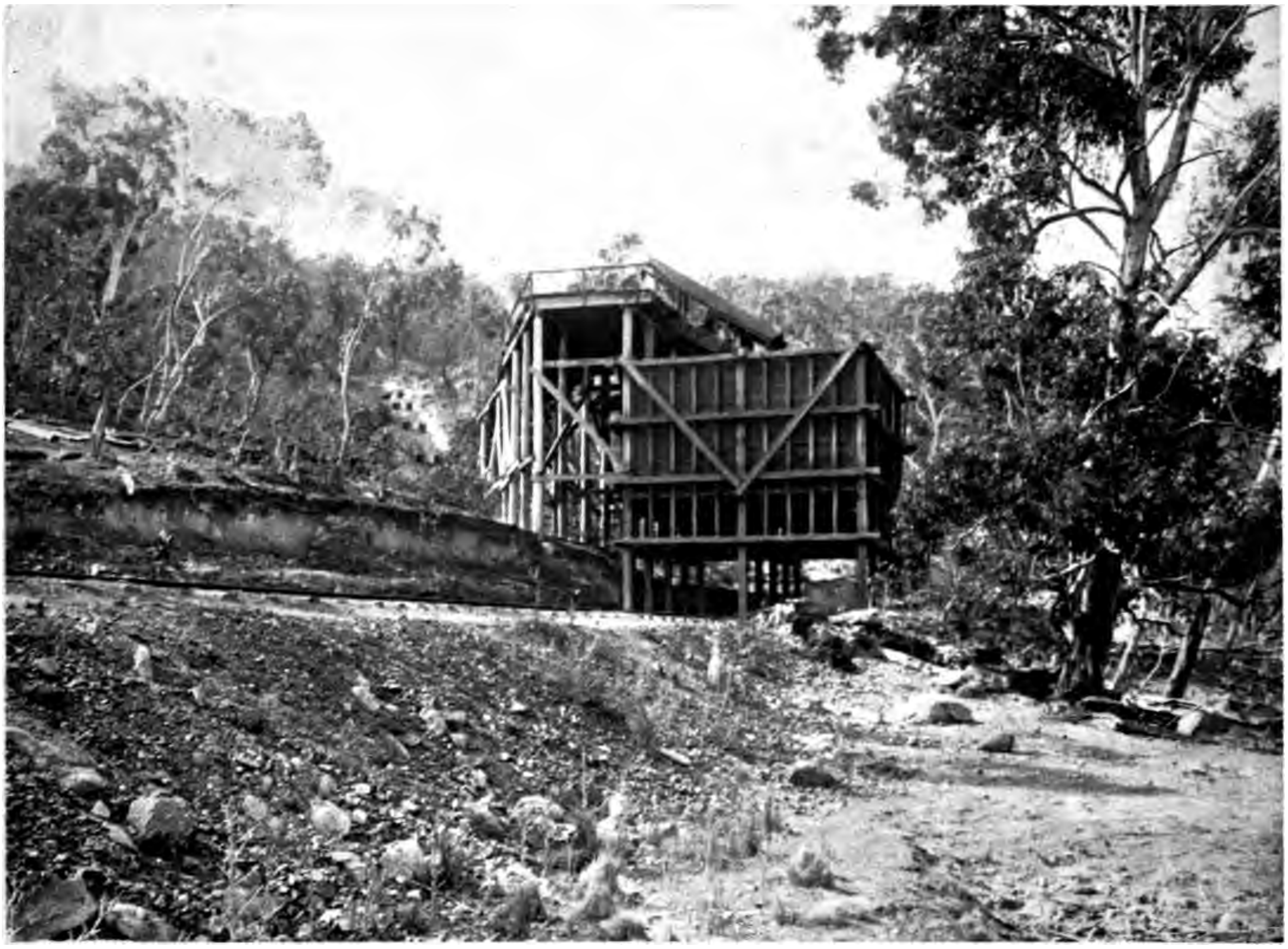
No. 6441 (exclusive of bands).

Hygroscopic moisture...	... 3·08
Volatile hydrocarbons	... 25·80
Fixed carbon	... 53·84
Ash	... 17·28
	100·00

Sulphur in coal	... 0·370	per cent.
Specific gravity	... 1·432	,,
Calorific power	... 10·4	,,

No true coke. Pulverulent.
Ash—White; semi-granular.

PLATE XXIII.



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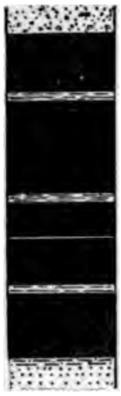
IVANHOE COLLIERY PIPER'S FLAT, LOADING STAGE AND SKIP LINE

At thirty-seven chains from the tunnel mouth, eastward towards Irondale Colliery, the working face yielded the following section and analysis :—

Fig. 56.



ft.	in.	
....		Sandstone and conglomerate roof.
1	3	Coal.
0	3	Band.
2	0	Coal.
0	1	to 2½ in. Band.
0	9	Coal.
0	0½	Band.
1	0	Coal.
0	2	Band.
1	6	Coal.
....		Floor.

Proximate Analysis.—W. A. Greig.

No. 4250 (exclusive of bands).

Hygroscopic moisture	4·16
Volatile hydrocarbons	26·62
Fixed carbon	50·14
Ash	19·08
	100·00

Coke—No true coke. Caked slightly on coking.
Sulphur in coal .... 0·398 per cent.
Specific gravity .... 1·407.
Calorific power.—1 lb. of this coal will convert 10·4 lb. of water into steam.

Ivanhoe Colliery.—16 on Map of Western Coal-field. Lower Seam (Lithgow).

Section, East District.

		ft.	in.
Sandstone and conglomerate roof.			
Coal		1	0
Band	3 in. to	0	5
Coal		1	11
Band	½ in. to	0	1½
Coal		1	7
Band	1 in. to	0	1½
Coal		1	8
Floor.			
		6	6½

Proximate Analysis.—W. A. Greig.

No. 6437 (exclusive of bands).

Hygroscopic moisture	3·08
Volatile hydrocarbons	28·05
Fixed carbon...	55·67
Ash	13·20
	100·00

Sulphur in coal ... 0·494 per cent.
Specific gravity ... 1·403
Calorific power ... 10·6
Coke—Formed a compact brittle mass on heating in closed crucible.
Ash—White, flocculent.

Ivanhoe Colliery.—Lower Seam (Lithgow).

Section, Main Heading.

		ft.	in.
Sandstone and conglomerate roof.			
Coal		0	7½
Band		0	3
Coal		1	11
Band	1 in to	0	1½
Coal		0	10
Band	¼ in to	0	0½
Coal		0	11
Band	1 in to	0	1½
Coal		1	5
Floor.			
		6	1¼

Proximate Analysis.—W. A. Greig.

No. 6438 (exclusive of bands).

Hygroscopic moisture	2·70
Volatile hydrocarbons	29·00
Fixed carbon...	57·32
Ash	10·98
	100·00

Sulphur in coal .... 0·494 per cent.
Specific gravity ... 1·391
Calorific power ... 11·2
Coke—Formed a compact brittle mass on heating in closed crucible.

Average Results of Analyses.

The average composition of the Irondale Lower Seam ("Lithgow"):—

Hygroscopic moisture	3·50	
Volatile hydrocarbons	26·22	
Fixed carbon	55·11	(3 assays)
Ash	15·17	
	100·00	

Sulphur in coal, 0·434.
Specific gravity, 1·411.
Calorific power, 10·9.

Average composition of the Ivanhoe Lower Seam ("Lithgow"):—

Hygroscopic moisture	3·31	
Volatile hydrocarbons	27·86	
Fixed carbon	54·38	(3 assays)
Ash	14·42	
	99·97	

Sulphur in coal, 0·462.
Specific gravity, 1·40.
Calorific power, 10·7.

Average composition of Irondale Upper Seam:—

Hygroscopic moisture	2·95	
Volatile hydrocarbons	33·98	
Fixed carbon	47·87	(4 assays)
Ash	15·20	
	100·00	

Sulphur in coal, 0·512.
Specific gravity, 1·375.
Calorific power, 11·3.

Average composition of Irondale and Ivanhoe coals compared with average Lithgow coals.

	Irondale.	Ivanhoe.	Lithgow.
Hygroscopic moisture	3·50	3·31	1·83
Volatile hydrocarbons	26·22	27·86	31·40
Fixed carbon	55·11	54·38	54·62
Ash	15·17	14·42	12·12
	100·00	99·97	99·97
Sulphur in coal	0·434	0·462	0·655

The upper seam worked at Irondale, and proved by short tunnel in the Portland Colliery, has been pierced in the intermediate Ivanhoe property in the air-shaft at sixty-two feet above the working seam. (For section of the latter, see page 183.)

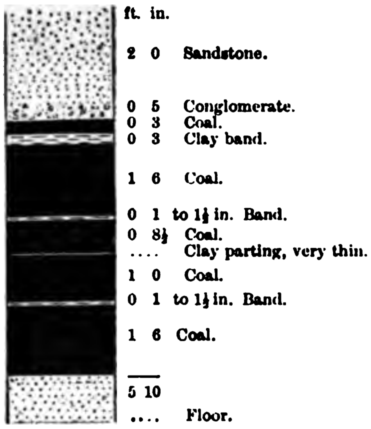
At Carlo's Gap, twenty-seven miles further along the Mudgee railway line, the upper seam occurs about eighty feet above the Lithgow. (For section, see page 214.)

Portland Collieries, M.P. 6, Parish Cullen Bullen, County Roxburgh. Situated about thirty chains north-easterly from Portland Railway Station, on the Mudgee Railway. Elevation, about three thousand one hundred feet above sea level. No. 22 on Map of Western Coal-field.

The lowest ("Lithgow") seam has been opened by tunnel for about one hundred and seventy yards north seventy degrees east. The upper (sixty feet above) for a distance of about forty yards.

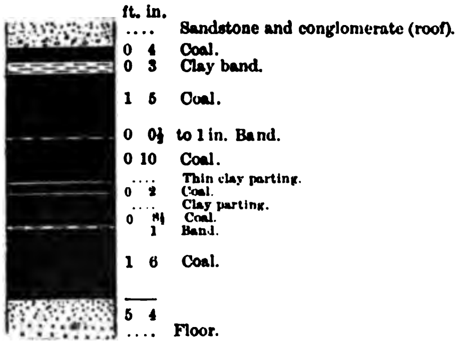
The following section was measured at the lower tunnel entrance in the main seam:—

FIG. 57.



The working face at one hundred and seventy yards gave the following section, from which an average sample, exclusive of bands, yielded the results herein recorded:—

FIG. 58.



Proximate Analysis—W. A. Greig.

No. 4248 (exclusive of bands).

Hygroscopic moisture	4·47
Volatile hydrocarbons	27·08
Fixed carbon	54·38
Ash	14·07
	100·00

Coke—No true coke formed.
Sulphur in coal, 0·521 per cent.
Specific gravity, 1·401.
Calorific power—1 lb. of this coal will convert 11·7 lb. of water into steam.

Invincible Colliery, Mineral Lease 2, Parish Cullen Bullen, County Roxburgh. No. 15 on Map of Western Coal-field. Adjoining the Cullen Bullen Colliery, on the Mudgee Road. About one mile and a half from the Mudgee Railway Line, at a point one hundred and fourteen miles from Sydney, and ten from Wallerawang; connected by tramway. Elevation, about two thousand nine hundred and ninety feet above sea-level.

Of the coking qualities of this coal, Mr. Mingaye—who made special laboratory tests—reports :—

Coke—Fairly well swollen, fairly firm, lustrous.
Ash—Nearly white, semi-granular.
Calorific power—1 lb. of this coal will convert 11·3 lb. of water into steam.

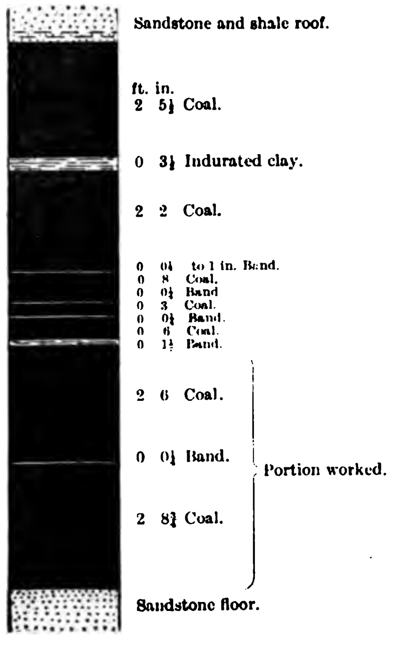
Cullen Bullen Colliery (closed) adjoins the Invincible. The seam presents about the same section as in the latter. The following analysis of Cullen Bullen coal is taken from " Mineral Resources."[1]

Hygroscopic moisture	1·25
Volatile hydrocarbons	34·15
Fixed carbon	51·95
Ash	12·65
	100·00

Sulphur in coal, 0·645 per cent.
Specific gravity, 1·348.
Coke, 64·60 per cent. Coke not much swollen, fairly bright, firm, covered with cauliflower-like excrescences.
Ash—white; granular, with some flocculent patches.
Calorific power—1 lb. of this coal will convert 12·1 lb. of water into steam.

" LITHGOW " SEAM, formerly worked by the Cullen Bullen Colliery Company, at Cullen Bullen. [After Mackenzie.[2]

FIG. 61.



* *Proximate Analysis.*

Hygroscopic moisture........... ..	1·25
Volatile hydrocarbons	31·15
Fixed carbon	51·95
Ash	12·65
	100·00

Sulphur in coal...... ·645 per cent.
Specific gravity.. ... 1·318
Calorific power ...... 12·1
Coke not much swollen, fairly bright, firm.

Colliery purchased by the Western Associated Collieries, and closed in 1900.

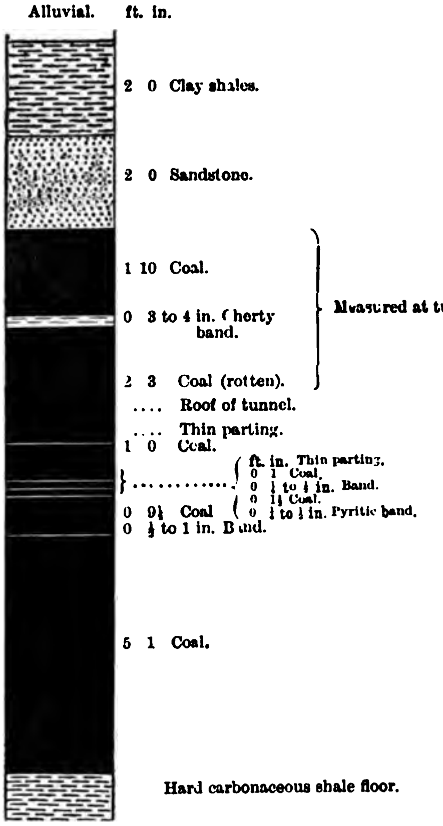
F P .man—1901, p. 344.

[2] Ann. Rept. Dept. Mines for 1888, p. 151.

* Mineral Resources N. S. Wales, 1901, p. 344.

Shepherd and Massey's tunnel, Mineral Lease 107, Parish Cullen Bullen, County Roxburgh. Driven for several hundred feet in the "Lithgow" coal-seam, but not worked. The following section was measured of the portion exposed in tunnel, and the outcrop at tunnel mouth :—

FIG. 62.



Proximate Analyses.—W. A. Greig.

No. 5964 (exclusive of bands).
Hygroscopic moisture .... 1·93
Volatile hydrocarbons .... 30·76
Fixed carbon .... 47·11 } Coke—
Ash .... 20·20 } 67·31 per cent.
100·00

No. 5964.
Coke—Slightly coked, not compact, dull lustre.
Ash—Nearly white ; semi-granular.
Sulphur in coal .... 0·672 per cent.
Specific gravity .... 1·415
Calorific power .... 11·0

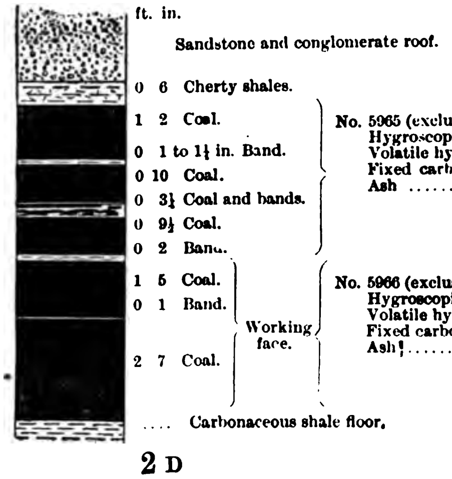
No. 5963.
Hygroscopic moisture .... 1·92
Volatile hydrocarbons .... 33·61
Fixed carbon .... 53·45 } Coke—
Ash .... 11·02 } 64·47 per cent.
100·00

No. 5963.
Coke—Not much swollen, firm, dull lustre.
Ash—Grey in colour ; semi-granular.
Sulphur in coal .... 0·590 per cent.
Specific gravity .... 1·355
Calorific power .... 12·2

Wallace's Commonwealth Colliery, No. 4 on Map of Western Coal-field, Parish Lidsdale, County Cook, on west bank of Cox's River, at crossing of Mudgee Road. Worked by tunnel in Lithgow seam. Maddox's Folly Colliery, 9 on Map, in the same seam is closely adjacent.

The following section and analysis from the Commonwealth Colliery sufficiently indicates thickness and quality in both.

FIG. 63.



Proximate Analyses.—W. A. Greig.

No. 5965 (exclusive of bands).
Hygroscopic moisture ...... 1·65
Volatile hydrocarbons ...... 27·35
Fixed carbon ...... 56·27
Ash ...... 14·73
100·00

No. 5955.
No true coke.
Ash—White ; semi-granular.
Sulphur in coal .... 0·412 per cent.
Specific gravity .... 1·417
Calorific power .... 11·5

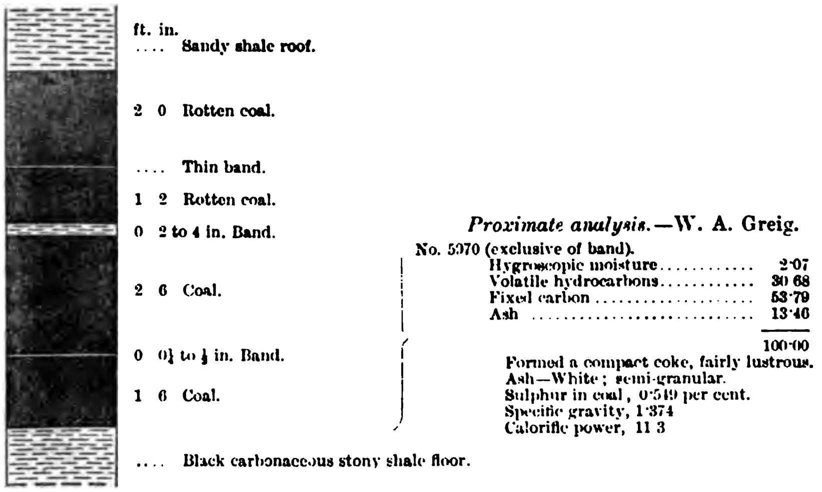
No. 5966 (exclusive of bands).
Hygroscopic moisture ...... 2·35
Volatile hydrocarbons ...... 26·75
Fixed carbon ...... 56·03
Ash ...... 14·87
100·00

No. 5966.
Slightly coked, not compact, dull lustre.
Ash—Grey ; semi-granular.
Sulphur in coal .... 0·658 per cent.
Specific gravity .... 1·41
Calorific power .... 0·7

Great Western Colliery, Mineral Lease 3, Parish Cullen Bullen, County Roxburgh. No. 11 on Map of Western Coal-field. Alongside Mudgee Railway Line, one mile beyond Cullen Bullen Station, which has an elevation of two thousand seven hundred and sixty-four feet above sea-level, the colliery being about one hundred feet higher.

Opened in 1905 by short tunnel. In the western face of **workings,** the following section was measured of the lower portion of the "**Lithgow**" seam :—

Fig. 64.



Proximate analysis.—W. A. Greig.

No. 5070 (exclusive of band).

Hygroscopic moisture	2·07
Volatile hydrocarbons	30 68
Fixed carbon	53·79
Ash	13·46
	100·00

Formed a compact coke, fairly lustrous.
Ash—White ; semi-granular.
Sulphur in coal, 0·549 per cent.
Specific gravity, 1·374
Calorific power, 11 3

Bulkeley's Colliery, Portion 68, Parish Cox, County Cook, **alongside** the Mudgee Road, between Lidsdale and Cullen Bullen. Opened about 1873; closed about 1876.

Two seams noted at this site by C. S. Wilkinson (Geological **Map** of Bowenfels, &c., 1875). The upper, six feet two inches thick (with five partings, together two inches thick), corresponds with the Upper Irondale and Black Diamond Seam.

The following section of the lower portion of "Lithgow" **seam** appears on the map mentioned :—

	ft. in.	ft. in.
Splint coal	1 9	3 1½
Bright coal	0 8	
Clay band	0 0¼	
Compact coal	0 8	

[1] Portion 113, one mile west-north-west of Cullen Bullen.

Shales and sandstone roof.	ft.	in.	
Coal	1	3	
Clay band	0	3	
Coal	1	0	Opened out for a short distance.
Band	0	1	
Coal	2	6	
Band	0	0½	
Coal	1	4	
	6	5½	

[1] Portion 189, four and a half miles south-south-west of Cullen Bullen.

Sandstone and conglomerate roof.	ft.	in.
Clay	0	3
Coal	1	6
Band	0	1
Coal	0	11
Bands and coal	0	2
Coal	0	10
Band	0	1
Coal	1	10
	5	5

[1] Portion 264, three miles south of Cullen Bullen.

Sandy shales (roof).	ft.	in.	
Coal (rotten)	2	0	
Band	0	3	
Coal	2	0	
Band	0	2	
Coal	0	9	
Coal and bands	0	3	
Coal	0	9	Opened for about 70 yards by tunnel.
Band	0	2	
Coal	2	10	
Band	0	0½	
Coal	1	9	
	10	11½	

Maddox's Folly Colliery, Portion 64, Parish Lidsdale, County Cook. Section after Mackenzie.[2] No. 9 on Map of Western Coal-field. (See also section on page 211):—

Conglomerate roof.	ft.	in.	
Indurated clay	0	2	
Splint coal	1	1	
Indurated clay	0	1	
Splint coal	1	11	
Band	......		
Splint coal	3	0	Portion worked.
Inferior coal	1	0	

---

[1] Measured by M. Morrison, Field Assistant.

[2] Ann. Rept. Dept. Mines for 1893, p. 88.

Average sample of working portion taken by Inspector of Collieries[1]:—

Hygroscopic moisture	1·52		
Volatile hydrocarbons	27·98	Sulphur	0·892
Fixed carbon	53·60	Specific gravity	1·422
Ash	16·90	Calorific power	11·1
	100·00		

No coke formed; only a fairly firm cake left after ignition.
Ash—greyish, granular.

Campbell Mitchell's tunnel in the same seam in Holt's 400 acres, opened about 1874, south-east of the present Folly Colliery, exposed the following section to J. Mackenzie[2]:—

Sandstone and conglomerate roof.	ft.	in.
Coal	2	3
Band	0	1½
Coal	0	7
Band	0	0⅛
Coal	0	10
	3	9⅝

Carlo's Gap Colliery (closed), No. 2 on Map of Western Coal-field. Portion 23, Parish Airly, County Roxburgh. Alongside Mudgee railway, thirty-two miles from Wallerawang, and one hundred and thirty-six from Sydney. Elevation, about two thousand five hundred and twenty-seven feet above sea-level.

Opened by tunnel in the "Lithgow" seam in 1884; closed in 1903. Recorded output = one thousand nine hundred and forty-six tons.

The following section was recently measured in the tunnel by Mr. M. Morrison, Field Assistant:—

	ft.	in.
Coal	2	7
Clay band	0	2
Coal	1	0
Clay band	0	1
Coal	1	2
Clay band	0	2
Coal	2	3
	7	5

---

[1] Mineral Resources N. S. Wales, 1900, p. 344.

[2] Ann. Rept. Dept. Mines for 1882, p. 133.

The upper seam ("Upper Irondale"), eighty feet above the main tunnel at Carlo's Gap, furnished the following section in a short tunnel:—

	ft.	in.
Coal	1	2
Band	0	2
Coal	1	3
Band	0	3
Coal	1	7
Band	0	3
Coal	1	0
	5	8

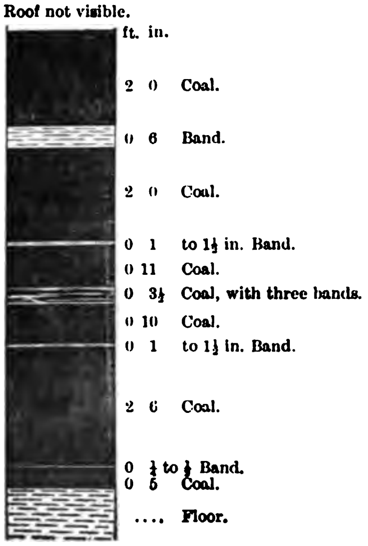
McDonald's Hole. Section measured by the late Inspector Rowan, at McDonald's Hole, about one mile from the Mudgee Railway Line, and twenty-eight from Wallerawang.

Prospecting tunnel in "Lithgow" coal-seam:—

	ft.	in.
Roof—Coal and bands	1	8
Coal	1	2
Band	0	1
Coal	1	2
Band	0	1
Coal	1	4
Band	0	1
Coal	1	2
	5	1

Torbane Tunnel Colliery, No. 20 on Map of Western Coal-field, Parish Airly, County Roxburgh. The connecting tunnel between the Airly Kerosene Shale deposit and the Torbane Retorts is driven in the "Lithgow" Coal-seam. From the tunnel, headings have been driven and bords opened up for the requirements of the retorting and transport plant. The following section shows the exposed thickness of the seam at this point, and the portion worked. Its full thickness has been proved to be about fourteen feet, including bands:—

Fig. 65.



Proximate Analyses—W. A. Greig.

No. 5969.	
Hygroscopic moisture	2·55
Volatile hydrocarbons	26·15
Fixed carbon	56·65
Ash	14·65
	100·00

No. 5969.
Coke—Slightly caked, not compact, dull lustre.
Ash—Nearly white; semi-granular.
Sulphur in coal...... 0·466 per cent.
Specific gravity ..... 1·434
Calorific power .... 11·12

No. 5968 (exclusive of bands).	
Hygroscopic moisture	2·19
Volatile hydrocarbons	29·91
Fixed carbon	50·59
Ash	17·31
	100·00

No. 5968.
Coke—Fairly compact, not much swollen, firm, and fairly lustrous.
Ash—Grey in colour; semi-granular.
Sulphur in coal...... 0·494 per cent.
Specific gravity ..... 1·390
Calorific power...... 10·6

No. 5967 (exclusive of bands).	
Hygroscopic moisture	2·17
Volatile hydrocarbons	84·48
Fixed carbon	52·45
Ash	10·90
	100·00

No. 5967.
Coke—Slightly caked, not compact, dull lustre.
Ash—Grey; semi-granular.
Sulphur in coal...... 0·439 per cent.
Specific gravity ..... 1·398
Calorific power...... 11·2

Proximate Analyses of samples selected by T. W. E. David.

No.	Assay No.	Locality.	Hygroscopic Moisture.	Volatile Hydro-carbons.	Fixed Carbon.	Ash.	Sulphur.	Coke (per cent.)	Calorific Power.	Remarks.	Specific Gravity.	Analyst.
I	91-168	Cumber Melon	2·62	31·00	56·76	9·02	·650	65·78	11·8	Coke—Fairly well swollen, firm, and fairly bright. Ash—Grey, flocculent.	1·368	J. C. H. Mingaye.
II	91-169	"	2·41	33·44	53·[illegible]	11·01	·61	64·15	11·01	Coke—Fairly well swollen, firm, and fairly bright. Ash—Grey, flocculent.	1·300	" "
III	91-170	"	2·61	30·02	56·91	10·46	·453	67·37	11·08	Coke—Fritted together, not very firm, not swollen, dull in colour. Ash—Grey, flocculent.	1·357	" "
A	·03 (see below).	"	2·50	31·08	55·84	10·58	·247	66·42	12·01	Coke—Fairly well swollen, firm, and lustrous. Ash—Grey and flocculent.	1·362	" "
	Average composition	..	2·53	31·53	55·06	10·27	·492	..	..			

Under the name of Commonwealth Coal-mine, one of the seams at Cumber Melon was further prospected, of which the Writer made the following record:—[1]

The Commonwealth Coal-mine is situated on the west side of Cumber Melon Range, alongside the Mudgee Railway, about five miles from Rylstone and three from Carwell Station.

Cumber Melon Range is a long narrow outlier of Upper Coal Measures, capped by the Hawkesbury Series, the latter in places also by patches of basalt. It is shown on the geological map of Mornington (Memoirs of Geological Survey, New South Wales, Geology No. 3). This range forms the divide between the east and west waters at the head of Capertee Valley. Several seams of coal occur, and about one foot of inferior oil-shale at the south end, where an ill-advised and abortive attempt was made to establish an oil industry by the late Mornington Oil Proprietary Company.

Near the site of the Commonwealth Coal Tunnel, a Mudgee-Rylstone syndicate drove several prospecting tunnels about twenty years ago, when a number of leases for coal-mining were granted. Attention was confined to the lowest or "Lithgow" coal-seam, which occurs immediately above the Marangaroo Conglomerate.

During the latter part of 1903, a party of working miners, under the leadership of Mr. J. McKay, extended the nearest tunnel to the railway to 100 feet from the entrance. At this point the following lower section was measured by me, and a careful average sample secured for analysis, excluding the three-inch shale band.

	ft.	in.		
			Sandy shale roof.	
	1	0	Perished coal	Measured at entrance of tunnel.
	2	7	Clay shales	
	0	9	Perished coal	
	0	4	Clay shale	
At 100 feet in tunnel.	1	9½	Coal	
	0	3	Band, thinning out in places...	
	1	4	Coal	
	0	0¼	Band	
	0	10	Coal	
	0	0½	to 2 in. Band	
	2	3	Coal	
	6	6½		

A—*Proximate Analysis.*

Hygroscopic moisture ...	2·50
Volatile hydrocarbons ...	31·08
Fixed carbon	55·84
Ash...	10·58
	100 00

Coke, 66·42 per cent., fairly well swollen, firm, and lustrous.
Ash, grey and flocculent.
Specific gravity, 1·362.
Sulphur in coal, 0·247.
Calorific power, 12·1.

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[1] Ann. Rept. Dept. Mines N. S. Wales for 1904, p. 42.

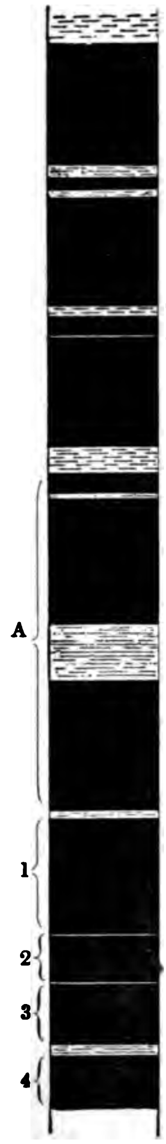
From the above analysis, the quality of the coal appears fully equal to the best Lithgow coal. From the physical appearance of the lower portion of the seam, it is probable that a higher percentage of volatile hydrocarbons could be obtained from it for gas purposes.

The party had formed a tramway grade to the railway line, but subsequently abandoned the undertaking, owing to failure to secure a siding from the Railway Commissioners, in consequence of the heavy haulage grade at this point.

RAWDON COLLIERY, Cox's Siding, Mudgee Railway Line.

Section of lowest, or "Lithgow" seam (after David, Ann. Rept. Dept. Mines for 1891, p. 214).

FIG. 67.



ft.	in.	
....		Roof, grey sandy shale.
2	7	Coal, clean hard splint, with a few layers of bituminous coal.
0	3	Band, fire-clay.
0	3	Coal, splint.
0	2	Band, grey fire-clay.
2	4	Coal, splint.
0	3	Band, coaly shale.
0	5	Coal, dirty splint.
0	0½	Band, brown clay.
2	4	Coal, splint, rather dirty.
0	7	Band, hard whitish-grey shale.
0	5	Coal, splint.
0	1½	Band, grey fire-clay.
2	8	Coal, splinty, with ½ in. clay band at 0 in. from top of layer.
1	3	Band, hard whitish-grey fire clay.
2	9	Coal, splint.
0	2½	Band, hard whitish-grey fire-clay.
2	6	Coal, hard splint, with streaks of bituminous coal.
0	0½	"Penny" band, brown shale and coal mixed.
1	0½	Coal, chiefly splint, with 2 in. of bituminous coal at bottom.
0	0½	Band, grey fire-clay.
1	3½	Coal, upper half bituminous, lower, splint.
0	3	Band, whitish-grey fire-clay.
1	2	Coal, splint and bituminous.

Portion of seam worked, 6 fee 4 inches.

Average Samples selected by T. W. E. David from Rawdon Colliery. (See section.)

No.	Assay No.	Locality.	Hygroscopic Moisture.	Volatile Hydro-carbons.	Fixed Carbon.	Ash.	Sulphur.	Coke (per cent.).	Calorific Power.	Remarks.	Specific Gravity.	Analyst.
*A	91-167	Rawdon Colliery	3·22	25·02	54·01	17·75	·532	71·76	10·7	Coke - Not swollen, dull in colour. Ash—White, flocculent.	1·402	J. C. H. Mingaye.
1	91-171	"	2·93	26·19	53·37	17·51	·450	70·88	8·1	Coke—Fritted together, not very firm, not swollen, dull in colour. Ash - Grey and flocculent.		
2	91-172	"	2·97	27·31	52·10	17·62	535	69·72	11·1	Coke and ash - As above.	1·436	"
3	91-173	"	4·01	31·06	51·46	13·47	·713	64·93	11·2	Coke - Slightly swollen, with cauliflower-like excrescences. Ash - Grey and flocculent.	1·385	"
4	91-174	"	3·22	31·54	57·19	8·05	·603	65·24	12·2	Coke and ash—As above.	1·360	"

* Exclusive of band.

WESTERN COAL COMPARED WITH SOUTHERN.

The two principal seams of the Western Coal-field, viz., the "Lithgow" and "Katoomba," resemble each other in composite character; bituminous layers in the upper part alternate with semi-bituminous and splinty. The latter, however, preponderate in the seam, and being dense and hard, determine the physical character of the coal.

The admixture of quick and slow burning coal renders it an excellent fuel for all varieties of work, as well as a relatively good gas producer.

Western coal is usually compared with Southern, though with the exception of the Hartley and Katoomba Collieries, the seams worked are not identical; the former is almost entirely won from the lowest, or Lithgow, the latter from the top, or Katoomba-Bulli.

The average composition of coal from ten collieries working the Top or "Bulli Seam" in the Southern Coal-field, is compared in the following table with that from seven collieries working the lowest or "Lithgow Seam" in Lithgow Valley, and with that from nine collieries working the latter in the Wallerawang-Cullen Bullen district.

The Western collieries are divided into two groups, because an average of the whole would operate to the disadvantage of the Lithgow Valley collieries to the extent of about one and three-quarters per cent. of ash. If the Piper's Flat collieries only were considered in the comparison with the latter, the disadvantage would be nearly three per cent. (see p. 205).

	Southern—10 Collieries.*	Western—7 Lithgow Collieries.	Wallerawang-Cullen Bullen—9 Collieries.
Hygroscopic moisture ...	·97	1·83	2·62
Volatile hydrocarbons ...	23·10	31·40	29·76
Fixed carbon...	65·26	54·62	53·82
Ash	10·67	12·12	13 79
	100·00	99·97	99·99
Sulphur in coal	·462	·655	·532

From this comparison the Bulli coal, because of its higher fixed carbon, appears to be the better steam coal, whilst the Lithgow, from its excess of volatile hydrocarbons, is the better gas coal. The Bulli, moreover, has the advantage of 1·45 per cent. less ash than the Lithgow; and 3·12 per cent. less than the Wallerawang group.

Proximity to the edge of the coal-basin may be accountable for the evident excess of mineral matter in the Lithgow coal-seam between Lidsdale and Portland, for there is marked improvement to the dip. Thus the lower portion of the seam in the Cullen Bullen and Invincible Collieries, and in Shepherd and Massey's tunnel in Mineral Lease 107, near Gardiner's Gap, yields an ash average of 11·74 per cent. against 15·62 per cent. in six other collieries nearer the margin. It must, however, be pointed out that this portion of the seam has relatively thinned in the latter.

Of the Wallerawang group, the Upper Irondale, Invincible, Cullen Bullen, and Shepherd and Massey's are the best gas coals, containing as they do 33·77 per cent. of volatile hydrocarbons against an average of 31·40 per cent. from Lithgow coal. With the exception of the Upper Irondale Seam, the ash contents of the other collieries mentioned average 11·74 per cent. against 12·12 per cent. for the Lithgow average. Whilst the percentage of volatile hydrocarbons is 2·34 per cent. better than the Lithgow average, the ash contents are ·38 per cent. less for the Cullen Bullen collieries.

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* E. F. Pittman, Min. Resources N. S. Wales, 1901, p. 343.

The coal of the Lithgow Seam is remarkable for abundant plant stems in the bedding planes; and for "Mother of Coal" or mineral charcoal, patches of which are soft, black, and fibrous.

The relative qualities of Lithgow and Piper's Flat coals have recently been brought into prominence in connection with State coal contracts. Analytical investigation affords valuable relative data when extended over considerable areas of working faces. Isolated tests must, however, be accepted as indicative of the particular spots sampled. Frequent analysis often demonstrates marked uniformity of grade for considerable distances, but the reverse sometimes happens.

As the Piper's Flat coal yielded relatively high ash percentages, fresh samples were carefully taken at an interval of a little over three months, from which the following results were obtained :—

IRONDALE COLLIERY—Upper Tunnel. North-east Heading.

No. of Analysis.	Colliery.	Hygroscopic Moisture.	Volatile Hydro-carbons.	Fixed Carbon.	Ash.	Sulphur.	Coke.	Calorific Power.	Specific Gravity.	Remarks.	Analyst.
06-6437	Ivanhoe—East District. "Lithgow Seam." Section. Roof. ft. in. in. Coal........... 1 0 Clay band ... 0 3-5 Coal........... 1 11 Band .... 0 0½-1½ Coal .... 1 7 Band .... 0 1-1½ Coal.... .... 1 8 Black shale (floor).	3·08	28 05	55·67	13·20	0·494	...	10·6	1·403	Exclusive of bands. Coke.—Formed a compact brittle mass on heating in closed crucible. Ash—White, flocculent.	W. A. Greig.
06-6138	Ivanhoe—Main Heading. "Lithgow Seam." Section. Roof. ft. in. in. Coal........... 0 7½ Band .... 0 3 Coal........... 1 11 Band .... 0 1-1½ Coal........... 0 10½ Band .... 0 0¼-½ Coal........... 0 11 Band .... 0 1-1½ Coal........... 1 5 Black shale (floor).	2·70	29·00	57·32	10·98	0 494	...	11·2	1·391	Exclusive of bands. Coke—Formed a compact brittle mass on heating in closed crucible. Ash—White, flocculent.	W. A Greig.
06-6439	Irondale—Upper Tunnel. North-east Heading. Section. Roof. ft. in. Coal .... 2 4 Band .... 0 2½ Coal .... 0 7 Band .... 0 0¼ Coal .... 0 8 Floor.	2·97	33·75	47·84	15·44	0·508	63·28	11·3	1·386	Exclusive of bands Coke—Fairly swollen, firm, and fairly lustrous. Ash—White, semi-granular.	W. A. Greig.

Irondale Colliery—Upper Tunnel. North-east Heading—*continued.*

No. of Analysis	Colliery.	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Coke.	Calorific Power.	Specific Gravity.	Remarks.	Analyst.
06-6440	Irondale—Upper Tunnel. (Right-hand Bord, North-east Heading). Section. Roof. ft. in. Coal .... 2 6 Band .... 0 2 Coal .... 0 7 Band .... 0 0½ Coal 0 9½	2·42	32·83	48·80	15·95	0·480	64·75	11·1	1·374	Exclusive of bands. Coke—Fairly swollen, firm, and fairly lustrous. Ash—White, semi-granular.	W. A. Greig.
06-6441	Irondale—Lower Tunnel. "Lithgow Seam." (No. 1 Left District.) Section. Roof. ft. in. Coal .... 1 0 Band .... 0 2 Coal .... 2 1 Band .... 0 1-1½ Coal .... 1 10 Band .... 0 3 Coal .... 1 2 Floor.	3·08	25·80	53 84	17·28	0·370	...	10·4	1·132	Exclusive of bands. No true coke. Pulverulent. Ash, white—semi-granular.	W. A. Greig.
06-6142	Irondale—Lower Tunnel. (Main Straight Heading.) Section. Roof. ft. in. in. Coal .... 0 8 Band .... 0 0½ Coal .... 2 0 Band .... 0 0¼-1 Coal .... 0 1½ Band .... 0 1 Coal .... 1 1 Band .... 0 0¼ Coal .... 0 8½ Band .... 0 1½-2 Coal .... 1 9½ Floor.	3·60	27·10	56·41	12·89	0·466	...	11·0	1·405	Exclusive of bands. Coke—Formed a compact brittle mass on heating in closed crucible. Ash—White, semi-granular.	W. A. Greig.
Average composition of Lower Seam at Irondale and Ivanhoe Collieries.		3·11	27·48	55 80	13·58	0·456	...	10·8	1·407	These figures practically confirm previous tests.	
Average of Upper Seam at Irondale.		2·69	33·29	48·32	15·69	0·494	...	11·2	1·380		

Composition of Coal Ashes (Lowest or Lithgow Seam), Lithgow Valley Collieries.[1]

Name of Colliery.	Ash.	Silica.	Alumina.	Iron Sesquioxide.	Manganese (MnO).	Lime.	Magnesia.	Potash.	Soda.	Phosphoric Acid.	Sulphuric Acid.	Undetermined and loss.	Analyst.
Bowenfels	11·40	69·15	29 65	·63	trace	·25	trace	·36	·32	·09	·22	..	Liversidge.
Eskbank	9·88	61·02	35·34	1·39	·78	·78	·61	..	..	·55	·16	..	Dixon.
,, ...	12·91	62·15	29·43	1·20	trace	1·35	1·73	2·10	·19	·05	1·12	..	Liversidge.
Lithgow Valley	9·68	60·21	36·26	1·42	..	·74	·57	..	..	·64	·11	·05	Dixon.
,, ,, ...	10·12	59·10	38·95	·40	trace	·85	·30	trace	trace	·20	·43	..	Liversidge.
Vale of Clwydd	9·72	58·25	37·46	1·55	trace	·81	1·05	..	..	·59	·17	·12	Dixon.
,, ,, ...	9·80	59·55	37·35	2 00	..	·53	trace	..	..	trace	·39	..	Liversidge.

Composition of Coal Ash from the Top or Katoomba Seam.

Katoomba	10·84	59·58	38·49	·98	trace	traces	·30	..	..	·56	..	·09	Dixon.

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[1] Reference.—Liversidge—Minerals of New South Wales, 1888, p. 141.

KEROSENE SHALE.

As this substance has recently been exhaustively treated by the Writer,[1] subsequent discoveries and developments alone are discussed herein.

The Kerosene Shale deposit of the Lower Capertee and Wolgan Valleys, in which the Commonwealth Oil Corporation is commencing operations, is undoubtedly the most extensive yet opened in the State, or elsewhere, as regards area. The limit of workable thickness will, however, considerably curtail the actual extent, though without impairing the above statement.

In the Western Coal Measures other deposits may occur where, owing to disappearance of the Measures beneath channel dissection, natural exposures are unavailable. In such areas discovery of isolated patches will be dependent on actual sinking or boring operations, governed largely by chance.

It, moreover, appears probable from the persistent marginal distribution of practically all known occurrences in the State, that chance of discovery will prove inversely proportional to distance from the edge of the coal-basin, where, perhaps, shallow lagoon-like conditions afforded most propitious environment for development of the gelatinous alga constituting the bulk of kerosene shale.

In regard to the outlook of the Kerosene Shale export and retorting industry in the State, the Writer's views[2] have been in nowise altered by the operations of the subsequently initiated Commonwealth Oil Corporation (Limited). On the contrary, further warning of the necessity for concentration of energy and cost is needed, if success is to be achieved. Development should proceed along definite, well-matured lines; for, under the most favourable conditions, the local industry offers but moderate returns on reasonable outlay.

Additional large areas have been taken up east and west of the Commonwealth property, by the Australasian Shale and Oil Company.

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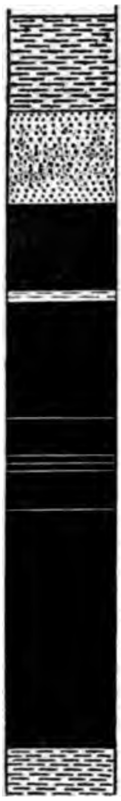
[1] Mem. of Geol. Survey N. S. Wales, Geol. 3, 1903.

[2] *Ibid.*, pp. 303 305.

Shepherd and Massey's tunnel, Mineral Lease 107, Parish Cullen Bullen, County Roxburgh. Driven for several hundred feet in the "Lithgow" coal-seam, but not worked. The following section was measured of the portion exposed in tunnel, and the outcrop at tunnel mouth :—

FIG. 62.



Proximate Analyses.—W. A. Greig.

No. 5964 (exclusive of bands).

Hygroscopic moisture	1·93	
Volatile hydrocarbons	30·76	
Fixed carbon	47·11	Coke—
Ash	20·20	67·31 per cent.
	100·00	

No. 5964.
Coke—Slightly coked, not compact, dull lustre.
Ash—Nearly white ; semi-granular.

Sulphur in coal	0·672 per cent.
Specific gravity	1·415
Calorific power	11·0

No. 5963.

Hygroscopic moisture	1·92	
Volatile hydrocarbons	33·61	
Fixed carbon	53·45	Coke—
Ash	11·02	64·47 per cent.
	100·00	

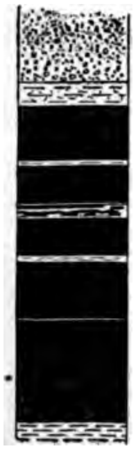
No. 5963.
Coke—Not much swollen, firm, dull lustre.
Ash—Grey in colour ; semi-granular.

Sulphur in coal	0·590 per cent.
Specific gravity	1·355
Calorific power	12·2

Wallace's Commonwealth Colliery, No. 4 on Map of Western Coal-field, Parish Lidsdale, County Cook, on west bank of Cox's River, at crossing of Mudgee Road. Worked by tunnel in Lithgow seam. Maddox's Folly Colliery, 9 on Map, in the same seam is closely adjacent.

The following section and analysis from the Commonwealth Colliery sufficiently indicates thickness and quality in both.

FIG. 63.



Proximate Analyses.—W. A. Greig.

No. 5965 (exclusive of bands).

Hygroscopic moisture	1·65
Volatile hydrocarbons	27·35
Fixed carbon	56·27
Ash	14·73
	100·00

No. 5955.
No true coke.
Ash White ; semi-granular.

Sulphur in coal	0·412 per cent.
Specific gravity	1·417
Calorific power	11·5

No. 5966 (exclusive of bands).

Hygroscopic moisture	2·35
Volatile hydrocarbons	26·75
Fixed carbon	56·03
Ash	14·87
	100·00

No. 5960.
Slightly coked, not compact, dull lustre.
Ash—Grey ; semi-granular.

Sulphur in coal	0·658 per cent
Specific gravity	1·41
Calorific power	0·7

KEROSENE SHALE.

As this substance has recently been exhaustively treated by the Writer,[1] subsequent discoveries and developments alone are discussed herein.

VIE

Additional large areas have been taken up east and west of the Commonwealth property, by the Australasian Shale and Oil Company.

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[1] Mem. of Geol. Survey N. S. Wales, Geol. 3, 1903.

[2] *Ibid.*, pp. 303–305.

In this tunnel, where coal is in contact with rotten cherty shale, fine impressions of *Brachyphyllum* are frequent. Ironstone concretions after pyrites also occur.

If the Wolgan and Capertee outcrops are on the same geological horizon, as believed, then "rolls" or undulations must be anticipated between them, for the main tunnels would not meet on their present levels and inclinations. Between the main tunnel on the Capertee and that in M.P. 1, further east, the fall greatly exceeds the normal dip in that direction. This "roll" probably has a north-west and south-east strike, and will be encountered between the rivers.

Winning will be facilitated by occurrence of coal above and below the shale at Wolgan. The intervening clay shale above the lower coal is thinning towards the dip.

The following section, measured at nine hundred feet in the Wolgan main tunnel, reveals stratigraphical arrangement:—

	ft.	in.
Hard coaly shale	0	4
Bituminous shale	0	2
Stony coal	0	3
Bright bituminous coal, friable...	0	2½
Kerosene shale	1	4
Stony band (attached to kerosene shale)	0	2
Clay shale	0	9 to 15 inches.
Bituminous coal, with dirty bands and altered pyrites ...	2	4
Floor.		

Portion of the bottom coal holing might afford fuel for purposes other than locomotives. For the latter, excellent coal is obtainable in the Wolgan Seam, about seventy-five feet below the shale (see Appendix, page 253).

In connection with retorting tests of kerosene shale by Mr. H. L. Jene, Analyst in the Corporation's laboratory, it has been found that a useful ratio can be established—as regards *true* kerosene shale[1]—between the proportion of volatile hydrocarbons ascertained by analysis, and the quantity of oil obtainable by destructive distillation. In laboratory practice, it has been observed that doubling the amount of volatile hydrocarbons gives approximately the oil contents. Thus fifty per cent. of volatile hydrocarbons is equivalent to one hundred gallons of crude oil. Mr. W. Hall, Manager of the Torbane and Hartley Retorting Plants, states that in practical work the recoverable oil would be about five to six per cent. less.

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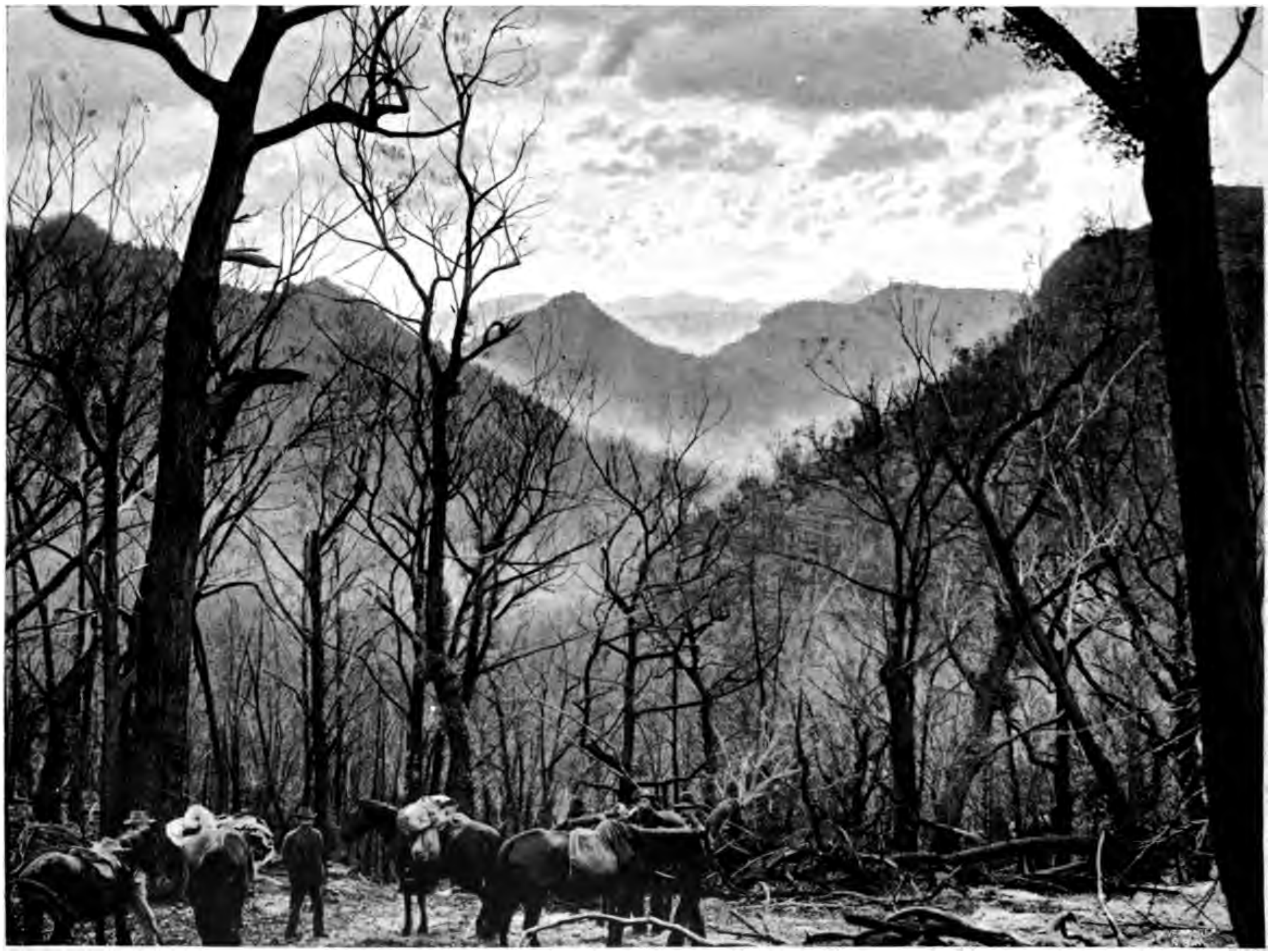
[1] The value of the ratio is dependent on the quality of the kerosene shale; and depreciates proportionately with increase of coaly matter.

PLATE XXVI.

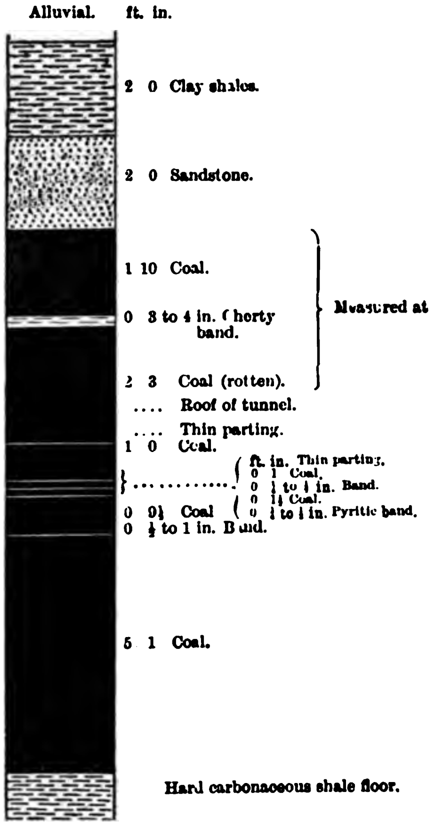


Kerry & Co.

VIEW FROM BRIDLE-TRACK NEAR GREEN'S GULLY CAPERTEE VALLEY LOOKING WEST THROUGH CANOBLA GAP.

Shepherd and Massey's tunnel, Mineral Lease 107, Parish Cullen Bullen, County Roxburgh. Driven for several hundred feet in the "Lithgow" coal-seam, but not worked. The following section was measured of the portion exposed in tunnel, and the outcrop at tunnel mouth :—

FIG. 62.



Proximate Analyses.—W. A. Greig.

No. 5964 (exclusive of bands).

Hygroscopic moisture	1·93	
Volatile hydrocarbons	30·76	
Fixed carbon	47·11	Coke—67·31 per cent.
Ash	20·20	
	100·00	

No. 5964.

Coke—Slightly coked, not compact, dull lustre.

Ash—Nearly white; semi-granular.

Sulphur in coal	0·672 per cent.
Specific gravity	1·415
Calorific power	11·0

No. 5963.

Hygroscopic moisture	1·92	
Volatile hydrocarbons	33·61	
Fixed carbon	53·45	Coke—64·47 per cent.
Ash	11·02	
	100·00	

No. 5963.

Coke—Not much swollen, firm, dull lustre.

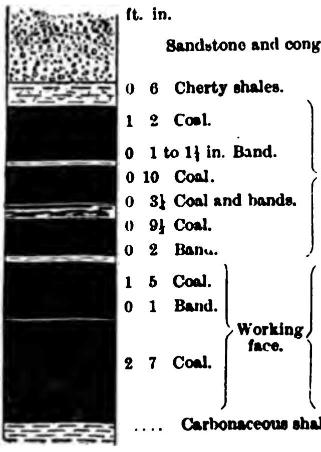
Ash—Grey in colour; semi-granular.

Sulphur in coal	0·590 per cent.
Specific gravity	1·355
Calorific power	12·2

Wallace's Commonwealth Colliery, No. 4 on Map of Western Coal-field, Parish Lidsdale, County Cook, on west bank of Cox's River, at crossing of Mudgee Road. Worked by tunnel in Lithgow seam. Maddox's Folly Colliery, 9 on Map, in the same seam is closely adjacent.

The following section and analysis from the Commonwealth Colliery sufficiently indicates thickness and quality in both.

FIG. 63.



Proximate Analyses.—W. A. Greig.

No. 5965 (exclusive of bands).

Hygroscopic moisture	1·65
Volatile hydrocarbons	27·35
Fixed carbon	56·27
Ash	14·73
	100·00

No. 5955.

No true coke.

Ash White; semi-granular.

Sulphur in coal	0·412 per cent.
Specific gravity	1·417
Calorific power	11·5

No. 5966 (exclusive of bands).

Hygroscopic moisture	2·35
Volatile hydrocarbons	26·75
Fixed carbon	56·03
Ash	14·87
	100·00

No. 5966.

Slightly coked, not compact, dull lustre.

Ash—Grey; semi-granular.

Sulphur in coal	0·658 per cent
Specific gravity	1·41
Calorific power	0·7

COKE.

Coke manufacture is a natural corollary of smelting; the steady demand likely to be created by the establishment of modern iron-smelting furnaces at Lithgow, will doubtless lead to careful coking tests, not only of the different coal-seams, but also of different portions of each, both vertical and horizontal, for it is well known that considerable variations in coking properties occur without recognisable physical change.

There appears to be no rule for determining coking qualities other than by practical test. Proximate or even ultimate analyses are not conclusive; they simply indicate the composition of any coke that may form.

Coals of widely-differing composition possess the property of caking or coking; others of closely approximating ultimates do not.

Others, again, coke when fresh, but lose the property on exposure.

Even at Lithgow where the collieries are all in the same seam and closely adjacent, it is known that certain localities yield better coking results than others. Mr. W. A. Dixon, F.I.C., F.C.S., states that "these coals are properly non-coking bituminous; although they will coke when fresh from the pit, they lose this property by exposure."[1]

Useful coke may also be prepared from a mixture of coking and non-coking coal slack.

Rapid heating is also capable of producing serviceable coke from a coal which fails to yield it under ordinary firing conditions.

The relatively high ash percentage of Western coals is a weighty factor in smelting problems, as it necessitates proportionate increase of flux and slag, and corresponding reduction of useful furnace capacity.

The average analyses of ten samples of local Lithgow coal equalled 65·7 per cent. of coke and 11·4 per cent. of ash. The average percentage of ash in the coke therefore works out at 17·3, as against 7 or 8 in best English coke.

To reduce this amount should be the aim of the coke manufacturer. With efficient washing appliances to prevent the possibility of shale waste entering the ovens, an important reduction of two or three per cent. of ash may be achieved.

---

[1] Ann. Rept. Dept. Mines for 1880, p. 36.

Average sample of working portion taken by Inspector of Collieries[1]:—

Hygroscopic moisture	1·52		
Volatile hydrocarbons	27·98	Sulphur	0·892
Fixed carbon	53·60	Specific gravity ...	1·422
Ash	16·90	Calorific power ...	11·1
	100·00		

No coke formed; only a fairly firm cake left after ignition.
Ash—greyish, granular.

Campbell Mitchell's tunnel in the same seam in Holt's 400 acres, opened about 1874, south-east of the present Folly Colliery, exposed the following section to J. Mackenzie[2]:—

Sandstone and conglomerate roof.	ft.	in.
Coal	2	3
Band	0	1½
Coal	0	7
Band	0	0⅛
Coal	0	10
	3	9⅝

Carlo's Gap Colliery (closed), No. 2 on Map of Western Coal-field. Portion 23, Parish Airly, County Roxburgh. Alongside Mudgee railway, thirty-two miles from Wallerawang, and one hundred and thirty-six from Sydney. Elevation, about two thousand five hundred and twenty-seven feet above sea-level.

Opened by tunnel in the "Lithgow" seam in 1884; closed in 1903. Recorded output = one thousand nine hundred and forty-six tons.

The following section was recently measured in the tunnel by Mr. M. Morrison, Field Assistant:—

	ft.	in.
Coal	2	7
Clay band	0	2
Coal	1	0
Clay band	0	1
Coal	1	2
Clay band	0	2
Coal	2	3
	7	5

---

[1] Mineral Resources N. S. Wales, 1900, p. 344.

[2] Ann. Rept. Dept. Mines for 1882, p. 133.

From the vats the washed and drained slack is discharged beneath into canister trucks supplying the ovens.

The necessary water supply is pumped from the lower dip levels of the colliery.

The following analyses have been made of selected samples of Oakey Park coke:—

	[1]	No. 5051 (W. A. Greig).
Hygroscopic moisture	4·12	2·62
Volatile hydrocarbons	2·10	·48
Fixed carbon	78·41	79·33
Ash	14·67	17·57
Sulphur	·70	...
	100·00	100·00
Specific gravity	2·711	1·656

No. 5051.—Phosphoric acid (P_2O_5) ... ... 0·364% = Phosphorus, 0·158%
Sulphur trioxide (SO_3) ... ... 0·089% = Sulphur, 0·035%

An important fact in connection with iron smelting is pointed out by J. C. H. Mingaye,[2] viz., that the ashes from New South Wales coals contain much less phosphoric and sulphuric acids than English.

The following report on the crushing resistance of Oakey Park coke was kindly obtained for the Writer by Mr. C. Sussmilch, Lecturer in Geology, Sydney Technical College:—

Sir,

I have the honor to report that I have made the following tests on cubes of coke submitted by you.

The tests were made at the Sydney Technical College, in the Olsen 25-ton testing machine.

Sizes of cubes—

A ... 1·79 inches x 1·79 inches x height 1·8 inches.
B ... 1·79 „ x 1·8 „ x „ 1·817 „
C ... 1·54 „ x 1·53 „ x „ 1·08 „

Results—

	lb. per square inch	Area of Cubes. Square inches.	Times. Minutes.	Rate of load applied per minute. lb.
A ...	2,329	3·2041	9	829·4
B ...	3,127	3·222	11	916·1
C ...	3,769	2·3562	7	1,267·5
	9,225	8·7823	27	3,013
Average...	3,075 lb. per sq. in.	2·9274 sq. in.	9 minutes.	1,004·3

The cube C, though the smallest, was of a better quality, being almost free from cracks, hence its better performance.

I have, &c.,

J. A. NANGLE, F.I.A.

---

[1] Mineral Resources N. S. Wales, 1901, p. 356.
[2] Ann. Rept. Dept. Mines for 1890, p. 304.

From the vats the washed and drained slack is discharged beneath into canister trucks supplying the ovens.

The necessary water supply is pumped from the lower dip levels of the colliery.

The following analyses have been made of selected samples of Oakey Park coke :—

	[1]	No. 5051 (W. A. Greig).
Hygroscopic moisture	4·12	2·62
Volatile hydrocarbons	2·10	·48
Fixed carbon	78·41	79·33
Ash	14·67	17·57
Sulphur	·70	...
	100·00	100·00
Specific gravity	2·711	1·656

No. 5051.—Phosphoric acid (P_2O_5) ... ... 0·364% = Phosphorus, 0·158%
Sulphur trioxide (SO_3) ... ... 0·089% = Sulphur, 0·035%

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Results—

	lb. per square inch	Area of Cubes. Square inches.	Times. Minutes.	Rate of load applied per minute. lb.
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B ...	3,127	3·222	11	916·1
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	9,225	8·7823	27	3,013
Average...	3,075 lb. per sq. in.	2·9274 sq. in.	9 minutes.	1,004·3

The cube C, though the smallest, was of a better quality, being almost free from cracks, hence its better performance.

I have, &c.,

J. A. NANGLE, F.I.A.

---

[1] Mineral Resources N. S. Wales, 1901, p. 356.
[2] Ann. Rept. Dept. Mines for 1890, p. 304.

LITHGOW VALLEY INDUSTRIES.

Cooerwull Woollen Mills, Bowenfels.

The following particulars of this, the first established industry, have been supplied by Mr. J. H. Gale, managing partner.

In 1848 the late Mr. Andrew Brown erected a three-storied flour mill at Cooerwull, and ran it for ten years. In 1858 he threw out the milling machinery, and commenced the manufacture of woollens, employing a small plant with hand-looms, power-looms being then unknown. A water-wheel supplied the motive power in both mills.

The woollen industry was continued under these conditions until 1874 or 1875, when a new mill, of double capacity, was erected, with up-to-date machinery, including power-looms. Some of the old hand-looms, however, were kept going for a few years longer. Owing to great improvements in the textile machinery installed, the output could be quadrupled at will.

The water-wheel, assisted by a small steam engine, supplied the motive power until 1896, when the wheel was discarded in favour of a larger boiler and engine.

The water supply in Cooerwull Brook was at one time abundant and good, but acidulated waste water from other industries higher up the Lithgow Valley rendered it unsuitable, the town supply now being requisitioned.

Since 1898, modern appliances have frequently been substituted for earlier and more primitive forms, and the mill run to its fullest capacity, namely, one hundred and fifty thousand yards of tweeds and flannels (chiefly the former) per annum. Thirty operatives are constantly employed, and it is hoped to more than double this number in the near future.

The coal supply is drawn from the Methven Colliery, working the "Lithgow" seam, on the property.

Iron Smelting.

The history of abortive attempts to establish the iron smelting industry in New South Wales at Mittagong and Lithgow is given by J. B. Jaquet in his work on Iron Ore Deposits.[1]

---

[1] Mem. Geol. Survey N. S. Wales, Geol. 2, 1901, pp. 1-4.

Smelting operations at Lithgow are stated to have been begun in October, 1875, and continued intermittently for several years, during which about twenty-two thousand tons of pig-iron were produced, the ores being local clay bands, and brown and magnetic oxides from Newbridge and Blayney. Limestone flux was procured from near Piper's Flat, now Portland.

Smelting operations at Fitzroy (Mittagong) began about 1852. According to Mr. Jaquet, probably less than eight thousand tons of pig-iron were produced. Nattai anthracite was tried at this furnace, but owing to inferior quality was discarded in favour of Bulli and Lithgow coke in the last attempt at smelting.

Lithgow operations proving unremunerative were discontinued, and the blast furnace pulled down—the plant being utilised for a short period on the co-operative system in re-rolling old rails.

In 1886 the Eskbank Works were take over by the present proprietor, Mr. W. Sandford, to whose energy and persistent efforts the present extensive operations of W. Sandford, Limited, are due.[1]

The following notes are extracted from a description of the enterprise in *Australasian Hardware and Machinery*, supplied by Mr. Sandford:—[2]

The iron works at present consist of the original eighteen-inch mill and steam hammer; a modern two and a half tons steam hammer; two puddling furnaces and five mill furnaces complete, connected with the eighteen-inch mill; a fourteen-inch mill and guide mill, with furnaces; a sheet mill with heating and annealing furnaces; another being converted into a twenty-four inch bar mill; galvanizing works with all machinery, including corrugator; two open-hearth Siemens steel furnaces; and a large steel foundry where castings of all descriptions up to five tons weight are manufactured. Steel ingots are made from three to seven cwt. each.

The workshops contain steam hammers, plate-bending rolls, punching and shearing machines, planing and drilling machines, and lathes. There is also a foundry for iron castings alone. In the latter, the tall seven-ton columns of the new blast furnace have been cast.

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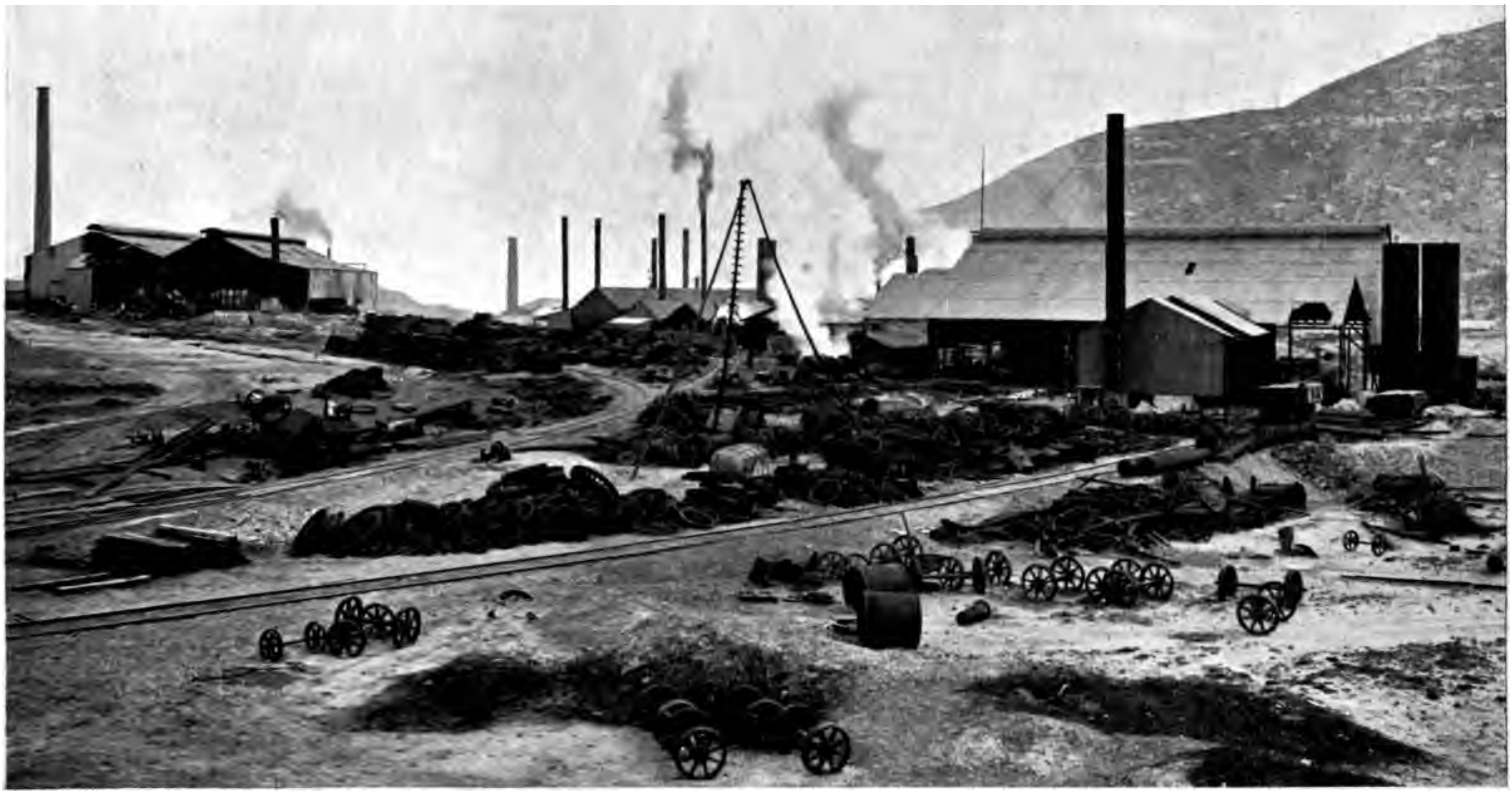
[1] The industry has now been taken over by Messrs. Hoskins, Brothers.

[2] Sept. 1, 1906, Vol. XXI, No. 9, pp. 268–270.

PLATE XXVII.



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SANDFORD LIMITED, IRON WORKS LITHGOW VALLEY.

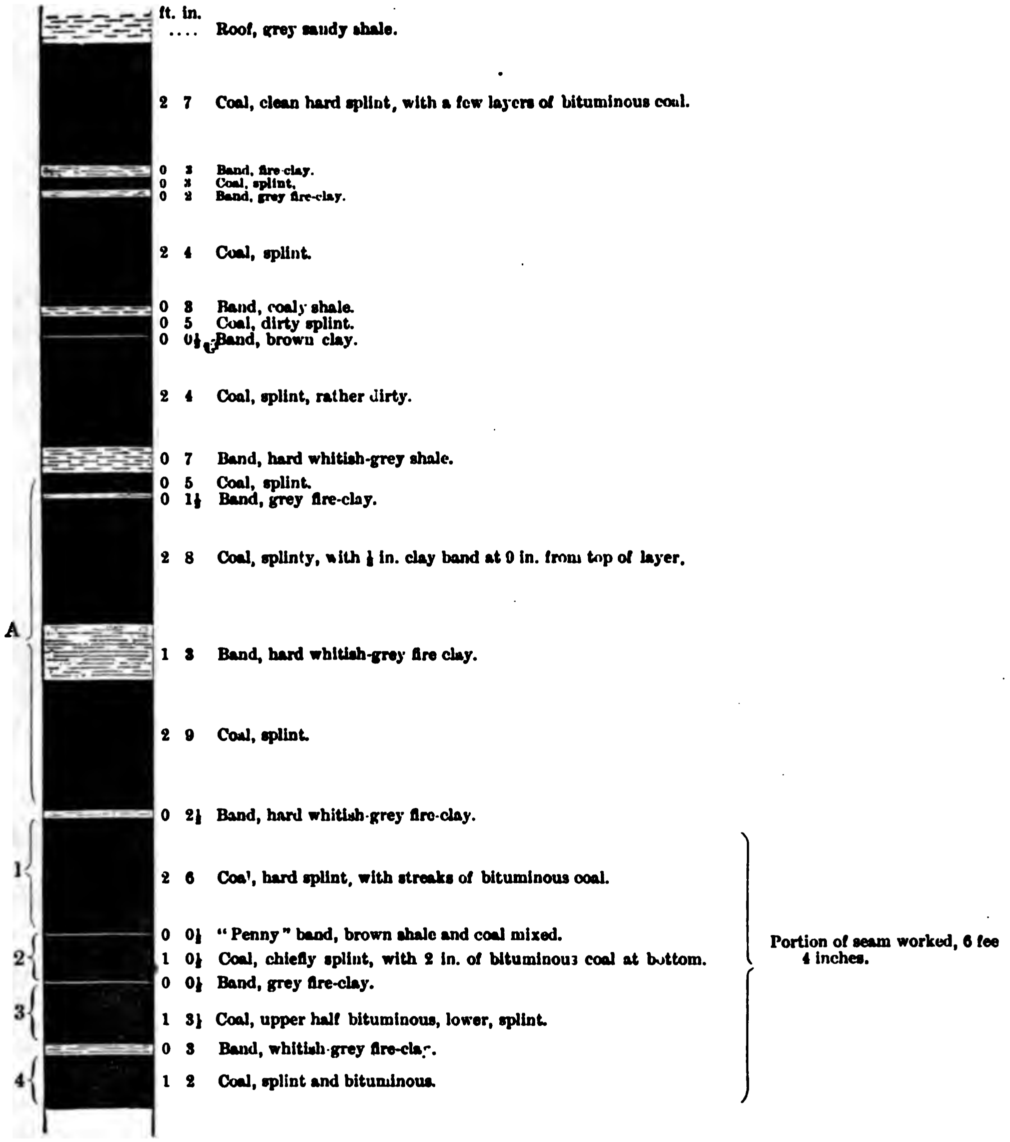
From the above analysis, the quality of the coal appears fully equal to the best Lithgow coal. From the physical appearance of the lower portion of the seam, it is probable that a higher percentage of volatile hydrocarbons could be obtained from it for gas purposes.

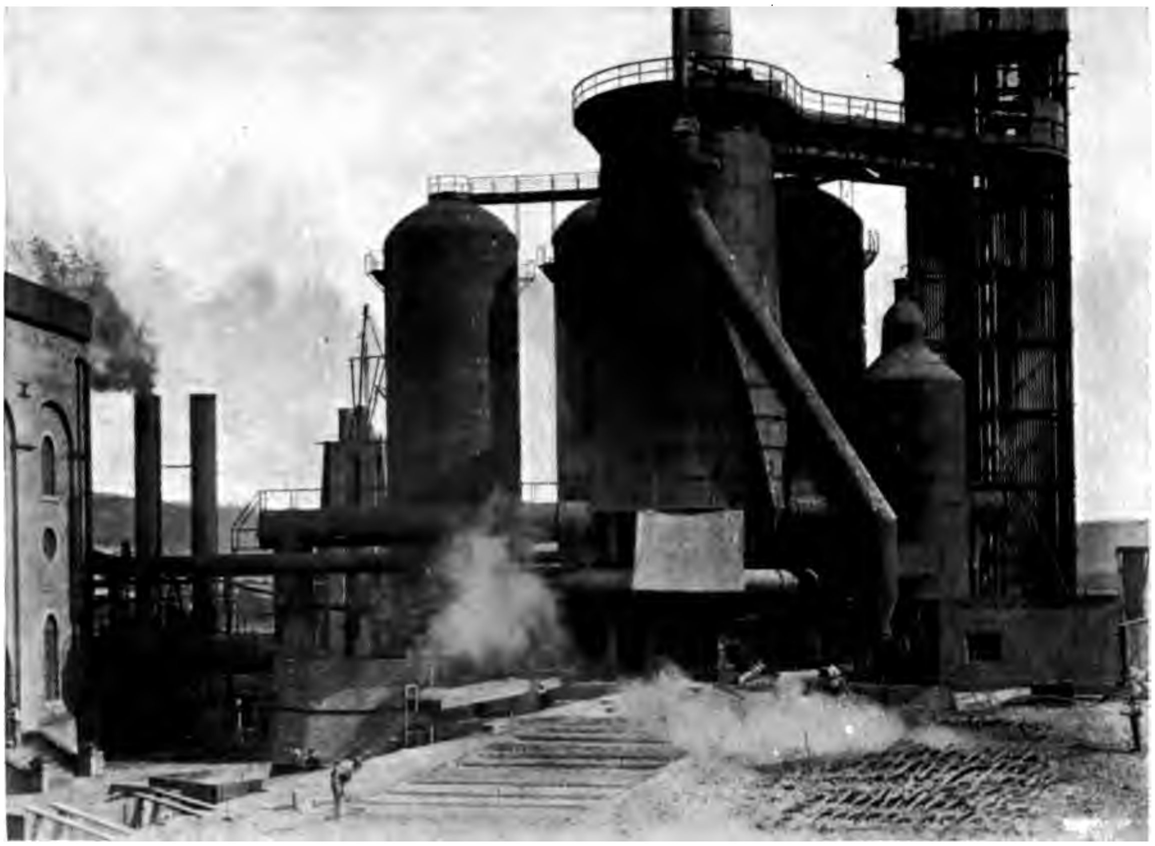
The party had formed a tramway grade to the railway line, but subsequently abandoned the undertaking, owing to failure to secure a siding from the Railway Commissioners, in consequence of the heavy haulage grade at this point.

RAWDON COLLIERY, Cox's Siding, Mudgee Railway Line.

Section of lowest, or "Lithgow" seam (after David, Ann. Rept. Dept. Mines for 1891, p. 214).

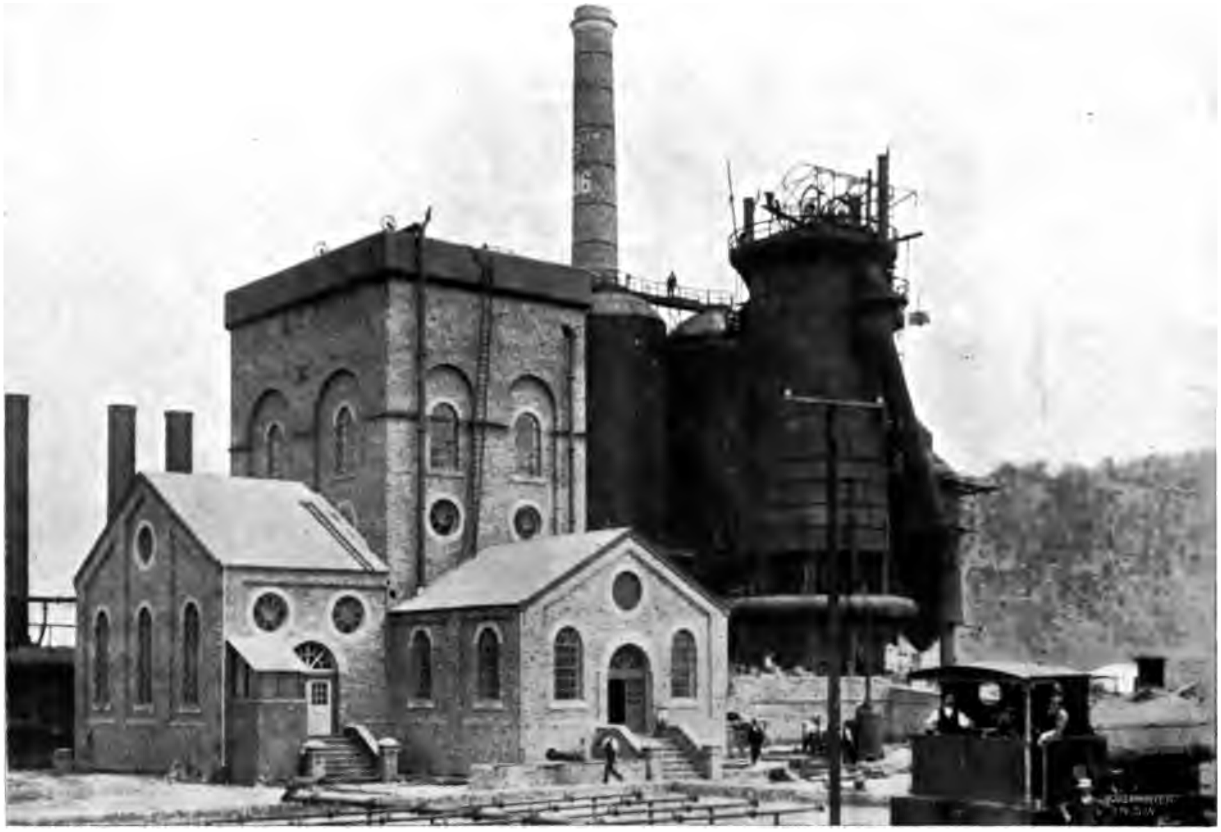
FIG. 67.


ft. in.
.... Roof, grey sandy shale.
2 7 Coal, clean hard splint, with a few layers of bituminous coal.
0 2 Band, fire-clay.
0 3 Coal, splint.
0 2 Band, grey fire-clay.
2 4 Coal, splint.
0 8 Band, coaly shale.
0 5 Coal, dirty splint.
0 0½ Band, brown clay.
2 4 Coal, splint, rather dirty.
0 7 Band, hard whitish-grey shale.
0 5 Coal, splint.
0 1½ Band, grey fire-clay.
2 8 Coal, splinty, with ½ in. clay band at 0 in. from top of layer.
1 3 Band, hard whitish-grey fire clay.
2 9 Coal, splint.
0 2½ Band, hard whitish-grey fire-clay.
2 6 Coa', hard splint, with streaks of bituminous coal.
0 0½ "Penny" band, brown shale and coal mixed.
1 0½ Coal, chiefly splint, with 2 in. of bituminous coal at bottom.
0 0½ Band, grey fire-clay.
1 3½ Coal, upper half bituminous, lower, splint.
0 3 Band, whitish-grey fire-clay.
1 2 Coal, splint and bituminous.
A
1
2
3
4
Portion of seam worked, 6 fee 4 inches.



G. H. Blakemore.

SANDFORD LIMITED IRON BLAST FURNACE, LITHGOW VALLEY.



SANDFORD LIMITED IRON BLAST FURNACE, LITHGOW VALLEY.

collieries to the extent of about one and three-quarters per cent. of ash. If the Piper's Flat collieries only were considered in the comparison with the latter, the disadvantage would be nearly three per cent. (see p. 205).

	Southern— 10 Collieries.*	Western— 7 Lithgow Collieries.	Wallerawang-Cullen Bullen— 9 Collieries.
Hygroscopic moisture ...	·97	1·83	2·62
Volatile hydrocarbons ...	23·10	31·40	29·76
Fixed carbon...	65·26	54·62	53·82
Ash	10·67	12·12	13 79
	100·00	99·97	99·99
Sulphur in coal	·462	·655	·532

From this comparison the Bulli coal, because of its higher fixed carbon, appears to be the better steam coal, whilst the Lithgow, from its excess of volatile hydrocarbons, is the better gas coal. The Bulli, moreover, has the advantage of 1·45 per cent. less ash than the Lithgow; and 3·12 per cent. less than the Wallerawang group.

Proximity to the edge of the coal-basin may be accountable for the evident excess of mineral matter in the Lithgow coal-seam between Lidsdale and Portland, for there is marked improvement to the dip. Thus the lower portion of the seam in the Cullen Bullen and Invincible Collieries, and in Shepherd and Massey's tunnel in Mineral Lease 107, near Gardiner's Gap, yields an ash average of 11·74 per cent. against 15·62 per cent. in six other collieries nearer the margin. It must, however, be pointed out that this portion of the seam has relatively thinned in the latter.

Of the Wallerawang group, the Upper Irondale, Invincible, Cullen Bullen, and Shepherd and Massey's are the best gas coals, containing as they do 33·77 per cent. of volatile hydrocarbons against an average of 31·40 per cent. from Lithgow coal. With the exception of the Upper Irondale Seam, the ash contents of the other collieries mentioned average 11·74 per cent. against 12·12 per cent. for the Lithgow average. Whilst the percentage of volatile hydrocarbons is 2·34 per cent. better than the Lithgow average, the ash contents are ·38 per cent. less for the Cullen Bullen collieries.

---

* E. F. Pittman, Min. Resources N. S. Wales, 1901, p. 343.

The boiler-feed pumps are capable of supplying five thousand gallons each per hour. Two Pearn water pumps installed are each capable of lifting twenty-two thousand gallons per hour at thirty revolutions.

An electric plant is also provided for lighting the works and driving an electric centrifugal pump for recovering the water from the creek.

The waste gases from the furnaces will be utilised in heating the cold blast and the steam boilers.

Forty thousand cubic yards of material have been excavated in the foundation work, and two thousand cubic yards of concrete put in. Five hundred tons of Commonwealth Portland cement have been used. Local bricks used and in order number one million three hundred thousand. Fire-clay, about three hundred tons, and a large quantity of lime.

The weekly output of pig-iron contemplated is about seven hundred and fifty tons, but the quantity can be doubled if required. Estimating the production at seven hundred tons per week, it represents one thousand three hundred tons of iron ore, equal to about fifty-four per cent. metallic; three hundred tons of limestone flax; and seven hundred and fifty tons coke fuel."[1]

Though the property embraces a colliery (the Eskbank or Iron Works), it is not proposed to manufacture the coke supply at present. A contract has been entered into with the Oakey Park Colliery Company, which has erected forty rectangular ovens in addition to the thirty-two Beehive ovens previously in use.

Definite arrangements have been made for smelting Coombing Park iron ore, and the iron quarries have been connected by standard gauge lines with the State railway near Carcoar.

The ore consists of hematite, limonite, and occasional magnetite, the estimated quantity being three million one hundred and sixty-eight thousand tons,[2] of an average composition:—

Iron	53·	per cent.
Silica	10·	„
Phosphoric acid (P_2O_5)	0·09	„

---

[1] The blast furnace was started on the 27th March, 1907, and the first pig-iron tapped on the 30th, since when it has run smoothly, the maximum output reaching nearly 800 tons per week.

[2] J. B. Jaquet, Mem. Geol. Survey N. S. Wales, No. 2, 1901, p. 25.

LOCAL IRON ORES.

The iron ores smelted in the Eskbank Iron Works in 1877 were procured from Back Creek, near Blayney; at a later date from Newbridge also, The so-called "clay bands" of the local Coal Measures were also utilised. It is recorded that Campbell Mitchell opened several of these bands near Bowenfels, and disposed of a considerable quantity to the Eskbank Iron and Coal Company at nine shillings per ton.[1]

The quality of the best "clay band" is shown in Note 1 on the geological map of Bowenfels, etc. (by C. S. Wilkinson, 1875).

The following analyses of ores of the principal clay bands are by Professor Liversidge.

The lowest (No. 1), of these clay bands is situated some twelve feet above the four feet six inches or upper coal-seam (at Piper's Flat.—J.E.C.), and No. 2 and 3 clay bands are a little above the first.

No. 1.—	Water, hygroscopic	1·28
	Water, combined	3·54
	Silica and insoluble, etc.	4·60
	Sesquioxide of iron[2]	80·00
	Phosphorus	·49
	Sulphur	·11
	Undetermined[3]	9·98
		100·00

No. 2.—Metallic iron ... ... 53·31 per cent.
No. 3.—Metallic iron ... ... 49·28 „

Note D refers to magnetic and micaceous iron ore associated with ferruginous garnet rock; about half a mile north-west of Mount Lambie; south of Portion 25, Parish Falnash, County Cook; held at that time by the Lithgow Iron Smelting Company, which proposed using it with the so-called clay band ore of the coal measures.

Of the Wallerawang iron ores, situated about three to four miles south of Portland, in Portions 150, 151, and 175, Mr. Wilkinson recorded the following in Note 7:—"Shaft sunk twenty-three feet deep (in portions 150, 151), in a mass of magnetite or magnetic oxide of iron, which at the surface has been proved to be not less than twenty-four feet in width, but the extent of the deposit has not been fully tested. The magnetite seems to occur in irregular masses rather than as a lode, and is associated with a hard siliceous garnet rock, which, in places, is highly ferruginous, containing about twenty-seven per cent. of metallic iron."[1]

---

[1] Ann. Rept. Dept. Mines for 1881, p. 127.
[2] Equal to fifty-six per cent. of metallic iron.
[3] Principally manganese, alumina, lime, and magnesia.

About 12 chains north-east is another shaft sunk ten feet deep in magnetite. The following is an analysis of the magnetic iron ore by Professor Liversidge :—

Silica and insoluble portion	18·70
Metallic iron	40·89
Phosphorus	traces.
Sulphur	traces.

About fifty chains from this deposit of magnetite, in a northerly direction, is a lode of brown hematite, and about thirty-seven chains further is another deposit of brown hematite. The former can be traced on the surface for about two hundred and fifty yards, varying in width from ten to fifteen feet or more. Professor Liversidge has given the following analysis of this ore from loose ore at shaft mouth :—

Water, hygroscopic moisture	2·74
Water, combined	9·70
Silica and insoluble matter	25·33
Sesquioxide of iron[2]	54·23
Phosphorus	·27
Sulphur	·12
Undetermined[3]	7·61
	100·00

Another sample of evidently picked ore, described as goethite and massive hematite, gave :—

Water, hygroscopic	1·28
Water, combined	12·04
Silica and insoluble	12·19
Sesquioxide of iron[4]	73·60
Phosphorus	·12
Sulphur	·06
Undetermined	·71
	100·00

---

[1] The Wallerawang iron deposits have since been described by J. B. Jaquet, A.R.S.M. (Mem. Geol. Survey N. S. Wales, 1901. No. 2, pp. 58, 59, 144.

[2] Equivalent to 37·84 per cent. of metallic iron.

[3] Principally manganese, alumina, lime, and magnesia.

[4] Equivalent to 51·52 per cent. of metallic iron.

COPPER SMELTING IN LITHGOW VALLEY.

The opening of collieries in Lithgow Valley, on completion of the railway across the Blue Mountains in 1869, led to the establishment of copper smelting plants at an early date. From Departmental records, it appears that the first was laid down in connection with T. Brown's Eskbank Colliery, about 1874-5. In the latter year, it was recorded that the Eskbank Copper Smelting Works were turning out fifty tons per month.

These works apparently dealt chiefly with regulus from other rented furnaces in the Cow Flat district.[1] Doubtless, ores were also purchased at the refining plant.

In 1876, copper smelting works were erected at the Vale of Clwydd Colliery, comprising two roasting and one refining furnace. A silver-lead furnace was also constructed. Copper ores were smelted from Eagle Swamp, and Armstrong's mine, near Lock's (Locksley) Platform.[2]

In 1877, the Eskbank Works turned out about six hundred and thirty tons of refined copper from Wiseman's Creek ores.[3]

Apparently, a good proportion of the regulus produced at many Western copper mines was refined at Lithgow. Most important, perhaps, was the Burraga supply, which still goes to Lithgow.

The Lloyd Copper Company, Limited, reduce Burraga ore to about thirty-nine per centum matte at the mine, and roast and refine at Lithgow, where the plant consists of three roasting and one refining furnace. Ores are purchased at the Lithgow establishment.

In the furnace-work ordinary local bricks are used in rough work; English and local fire-bricks in the furnaces; those imported for the crowns.

In 1895-6 the Great Cobar Syndicate erected a refinery at Lithgow, having secured coal land and opened a colliery; and, in 1900, added an electrolytic plant for separation of the gold and silver from the rough copper.

In August, 1906, the Syndicate's Cobar and Lithgow interests were transferred to the Great Cobar, Limited.

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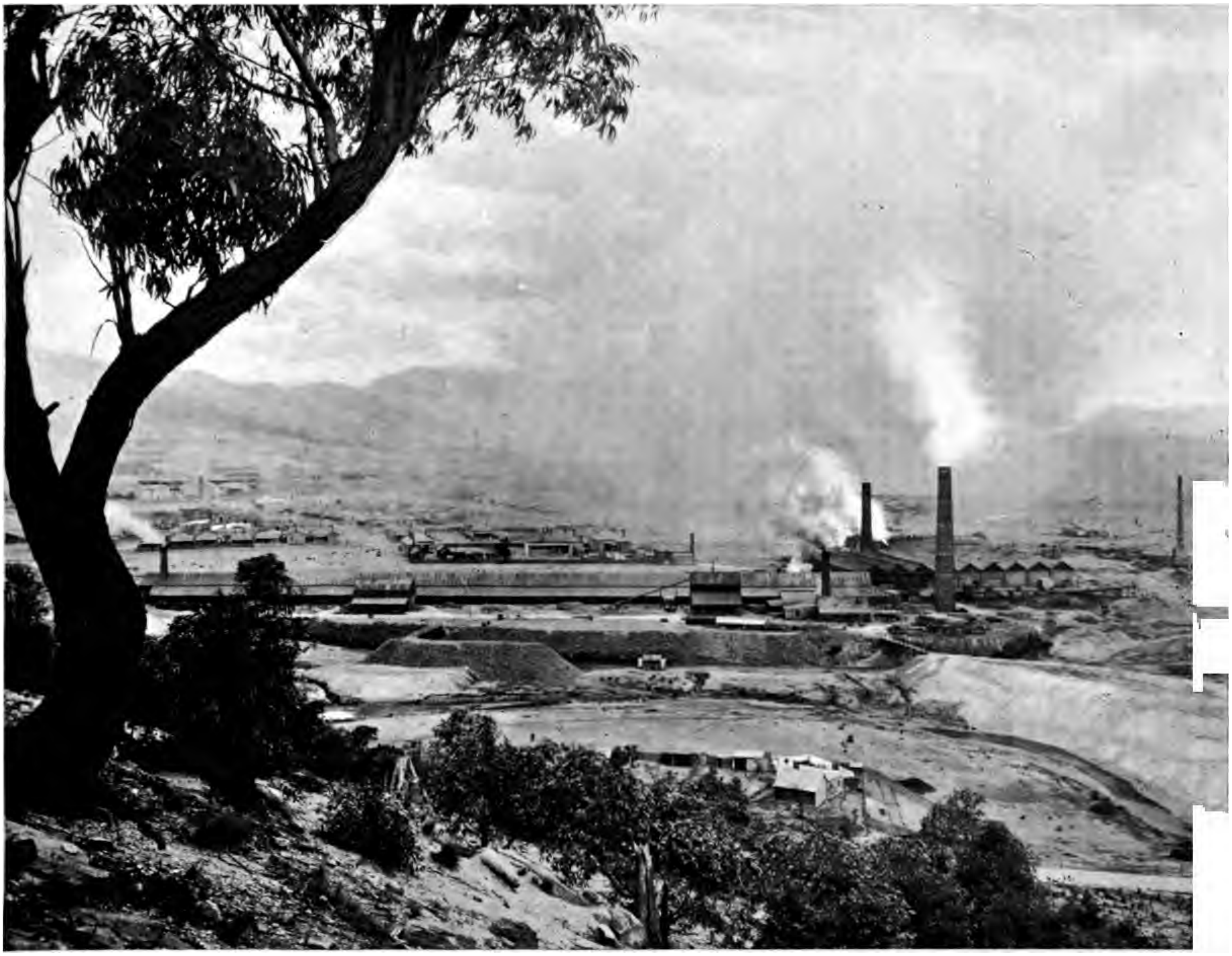
[1] Ann. Rept. Dept. Mines for 1875, pp. 59, 60

[2] *Ibid.*, 1876, p. 134.

[3] *Ibid.*, 1877, p. 179,



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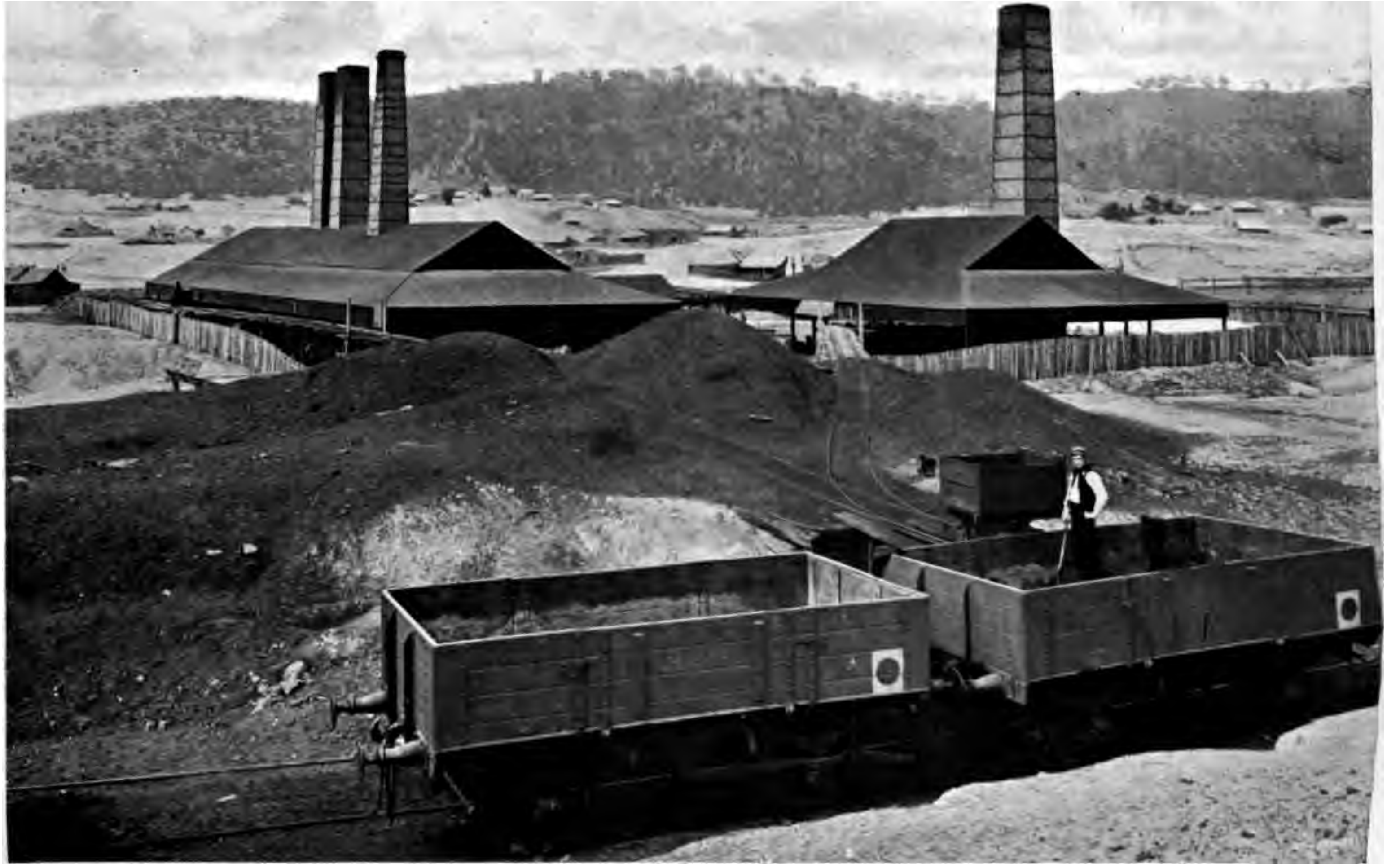
GREAT COBAR LIMITED, COPPER SMELTING AND ELECTROLYTIC PLANT, LITHGOW VALLEY.

PLATE XXX.



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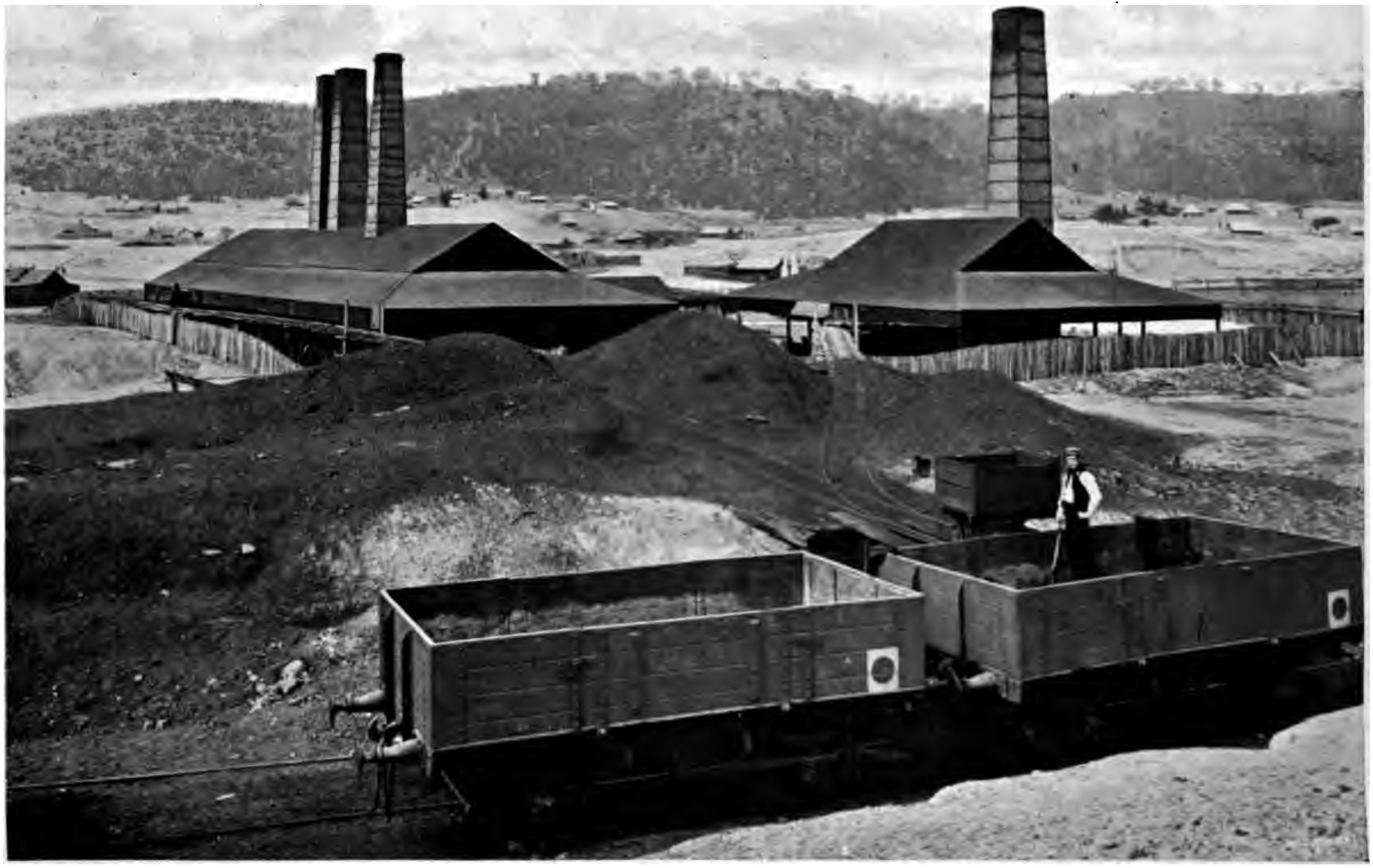
LLOYD COPPER MINING COMPANY'S REFINING PLANT, LITHGOW VALLEY.



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LLOYD COPPER MINING COMPANY'S REFINING PLANT, LITHGOW VALLEY.

Operations of the Commonwealth Oil Corporation (Limited).

A railway from the Great Western Line, at Newnes Junction, (eighty-six miles from Sydney) to connect with the Wolgan River shale workings, is being constructed of standard gauge, the distance being, approximately, thirty-one miles. For about nineteen miles over the plateau a good grade has been obtained, but the descent on a grade of one in twenty-five, into the precipitously-walled Wolgan Valley renders the undertaking costly, and traction severe, the fall amounting to nearly one thousand eight hundred feet.

Tunnels have been driven from the Capertee and Wolgan outcrops towards each other, for distances of two thousand five hundred and one thousand nine hundred and forty feet respectively. The Capertee tunnel (now abandoned) revealed gradual thinning of the Kerosene Shale seam from about two feet to about eight inches at two thousand five hundred feet, which was to be expected from approach towards the outcrop in Green's Gully, where an approximate thickness is exposed.

The tunnel in M.P. 1, however, in the thickest portion of the seam, discloses remarkable uniformity; thickness and quality being well maintained for over four thousand feet; an average thickness of over four feet of kerosene shale being exposed, two-thirds of which may, perhaps, be regarded as of first, or shipping, grade.

In the No. 1 tunnel in the Wolgan Valley, thickness and quality are persistent, for nearly two thousand feet, whilst near the site of Duff and Hartmann's discovery,[1] the thickness has increased to about twenty inches. Lower down the river, in No. 2 shaft, a thickness of two feet one and a half inches has been proved. In No. 3 shaft, still further down stream, there is diminution to thirteen inches.[2]

Between Shale and Capertee Gullies (where good kerosene shale occurs), considerable deterioration is manifest, the seam passing into coaly shale for some distance. On the south side of the river the outcrop is of similar character, but further east, in "West" tunnel, improves to a thickness of about fifteen inches of retorting grade.

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[1] Mem. Geol. Survey N. S. Wales, Geol. 3, 1903, pp. 177, 178.

[2] In the No. 2 or Main Tunnel, one thousand feet have been driven for an average thickness of about two feet. For recent developments see Appendix A, p. 251.

The Lithgow Valley Company's dry-pressed bricks are held in high repute; they are manufactured from Coal Measure shales about forty to sixty feet above the Lithgow Valley Colliery in the "Lithgow" seam.

The composition of the brick shale is shown in the following partial analysis by J. C. H. Mingaye:—

No. 399–06.

Moisture and combined water	12·86
Silica	52·70
Ferric oxide	·90
Ferrous oxide	7·92
Alumina[1]	21·48
Lime	·68
Magnesia	1·05
Potash	2·04
Soda	·21
	99·84

POTTERY CLAYS.

The Lithgow Valley Colliery Company formerly manufactured drain pipes on a considerable scale, clay from near Mount Clarence Railway Station being used for the purpose. It is identical with that exposed in the road cutting at the Recreation Pavilion, Mount Piddington, the quality of which is shown in the accompanying analysis by W. A. Greig:—

No. 138.

Water at 100° C.	·31
Water above 100° C.	6·26
Silica	62·96
Alumina	25·16
Titanic oxide	·20
Ferric oxide	1·30
Ferrous oxide	·27
Manganous oxide	·03
Lime	·18
Magnesia	·51
Soda	·40
Potash	2·13
Phosphoric anhydride	·09
Sulphur trioxide	absent.
Chlorine	trace.[2]
Chromium sesquioxide	·01
Vanadic oxide	trace.[2]
Lithia	absent.
	100·11

Specific gravity, 2·660.

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[1] Including any phosphoric and titanic acids present.

[2] Less than 0·01 per cent.

COKE.

Coke manufacture is a natural corollary of smelting; the steady demand likely to be created by the establishment of modern iron-smelting furnaces at Lithgow, will doubtless lead to careful coking tests, not only of the different coal-seams, but also of different portions of each, both vertical and horizontal, for it is well known that considerable variations in coking properties occur without recognisable physical change.

There appears to be no rule for determining coking qualities other than by practical test. Proximate or even ultimate analyses are not conclusive; they simply indicate the composition of any coke that may form.

Coals of widely-differing composition possess the property of caking or coking; others of closely approximating ultimates do not.

Others, again, coke when fresh, but lose the property on exposure.

Even at Lithgow where the collieries are all in the same seam and closely adjacent, it is known that certain localities yield better coking results than others. Mr. W. A. Dixon, F.I.C., F.C.S., states that "these coals are properly non-coking bituminous; although they will coke when fresh from the pit, they lose this property by exposure."[1]

Useful coke may also be prepared from a mixture of coking and non-coking coal slack.

Rapid heating is also capable of producing serviceable coke from a coal which fails to yield it under ordinary firing conditions.

The relatively high ash percentage of Western coals is a weighty factor in smelting problems, as it necessitates proportionate increase of flux and slag, and corresponding reduction of useful furnace capacity.

The average analyses of ten samples of local Lithgow coal equalled 65·7 per cent. of coke and 11·4 per cent. of ash. The average percentage of ash in the coke therefore works out at 17·3, as against 7 or 8 in best English coke.

To reduce this amount should be the aim of the coke manufacturer. With efficient washing appliances to prevent the possibility of shale waste entering the ovens, an important reduction of two or three per cent. of ash may be achieved.

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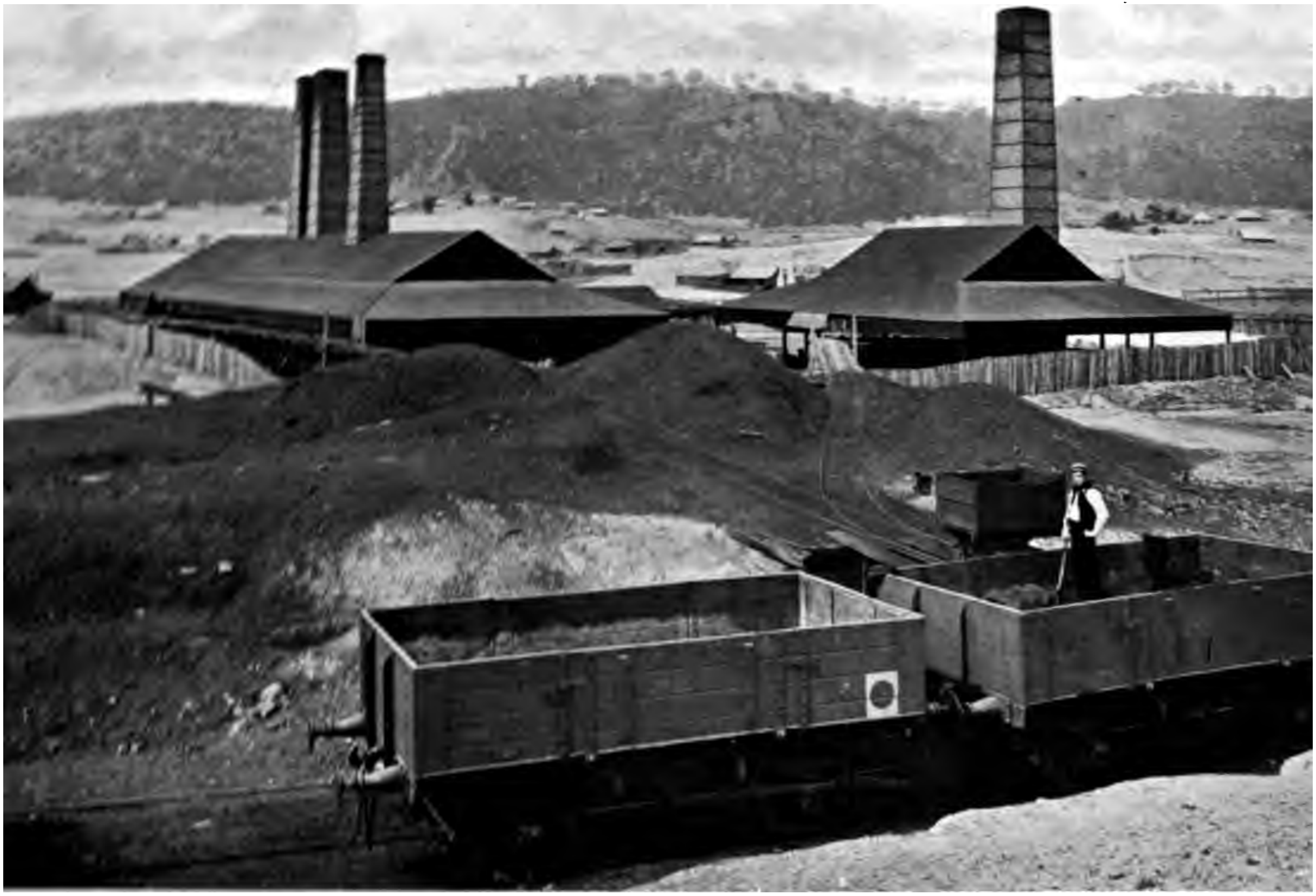
[1] Ann. Rept. Dept. Mines for 1880, p. 36.

PLATE



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LLOYD COPPER MINING COMPANY'S REFINING PLANT, LITHGOW VALLEY.

The General Manager—Mr. G. H. Blakemore—states that the Lithgow plant consists of seventeen reverberatory furnaces, of which two are used to refine rough copper to anodes, and two for re-melting cathode copper from the electrolytic plant to "E.L.C. ingots."

The furnaces are fired with coal got on the property.

The anode copper produced is refined in an electrolytic plant capable of treating about one hundred and thirty-five tons of copper in anode form each week.

There are six dynamos of sixty volts and one thousand two hundred ampères, and one of twenty-five volts and six hundred ampères.

Each of the large dynamos has, practically, one hundred tanks working; the small dynamo—which is used to remove excess of copper from the electrolyte—has but twelve tanks on it.

The anode copper is separated from its gold and silver contents, and sold as "E.L.C." copper with a conductivity of from ninety-nine to one hundred per centum; and the gold and silver is refined and separated by electricity.

FIRE, BRICK, AND POTTERY CLAYS.

The local Coal Measures afford excellent material for ordinary bricks, drain-pipes, tiles, &c., as well as good fire-clay. The Lithgow Valley Colliery Company, Limited (which owns also the Hermitage Colliery), in 1877[1] established works for manufacture of earthenware pipes, terra cotta, ordinary, and fire-bricks, &c. This portion of the company's plant is up-to-date, four large boilers and a one hundred and fifty horse-power engine affording the necessary power.

An eighteen-chamber Sercombe continuous barrel kiln is used for ordinary building bricks; and three specially designed kilns for fire-bricks.

Four large circular kilns for manufacture of glazed drain-pipes from four to twenty-four inches in diameter.

The Company also owns a pottery plant and runs complete blacksmithing, carpentry, and fitting-shops for requirements of collieries and works.

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[1] Ann. Rept. Dept. Mines for 1877, p. 178.

The boiler-feed pumps are capable of supplying five thousand gallons each per hour. Two Pearn water pumps installed are each capable of lifting twenty-two thousand gallons per hour at thirty revolutions.

An electric plant is also provided for lighting the works and driving an electric centrifugal pump for recovering the water from the creek.

The waste gases from the furnaces will be utilised in heating the cold blast and the steam boilers.

Forty thousand cubic yards of material have been excavated in the foundation work, and two thousand cubic yards of concrete put in. Five hundred tons of Commonwealth Portland cement have been used. Local bricks used and in order number one million three hundred thousand. Fire-clay, about three hundred tons, and a large quantity of lime.

The weekly output of pig-iron contemplated is about seven hundred and fifty tons, but the quantity can be doubled if required. Estimating the production at seven hundred tons per week, it represents one thousand three hundred tons of iron ore, equal to about fifty-four per cent. metallic; three hundred tons of limestone flax; and seven hundred and fifty tons coke fuel."[1]

Though the property embraces a colliery (the Eskbank or Iron Works), it is not proposed to manufacture the coke supply at present. A contract has been entered into with the Oakey Park Colliery Company, which has erected forty rectangular ovens in addition to the thirty-two Beehive ovens previously in use.

Definite arrangements have been made for smelting Coombing Park iron ore, and the iron quarries have been connected by standard gauge lines with the State railway near Carcoar.

The ore consists of hematite, limonite, and occasional magnetite, the estimated quantity being three million one hundred and sixty-eight thousand tons,[2] of an average composition:—

Iron	53·	per cent.
Silica	10·	„
Phosphoric acid (P_2O_5)	0·09	„

---

[1] The blast furnace was started on the 27th March, 1907, and the first pig-iron tapped on the 30th, since when it has run smoothly, the maximum output reaching nearly 800 tons per week.

[2] J. B. Jaquet, Mem. Geol. Survey N. S. Wales, No. 2, 1901, p. 25.

The phosphorus being in excess of the Bessemer limit, the basic smelting process will be necessary. For furnace hearths and converter linings, dolomite will be necessary.[1] So far, no important deposits have yet been noted in the State. As it is usually impossible to distinguish macroscopically between it and ordinary limestone, probably untested deposits have been mistaken for the latter. The demand having arisen, closer attention will be paid to such outcrops.

Near Cow Flat, in the Bathurst district, dolomite is associated with the well-known limestone of that locality. In texture it is much more homogeneous and dense than the associated crystalline or "sparry" limestone. A quantity of it has been quarried for the iron furnace at Lithgow. A partial analysis yielded the following results:—

No. 07-5,303.	Calcium carbonate ($CaCO_3$)	54·28
	Magnesium carbonate ($MgCO_3$)	39·34
	Ferric oxide and alumina $Fe_2O_3 + Al_2O_3$)... ...	0·46
	Gangue (sand, &c.)	5·78
		99·86

A sample of dolomite from Penberthy and Donnelly's Mine, Merrilla, in the Goulburn district, yielded the following return:—

No. 07-5,302.	Calcium carbonate	46·17
	Magnesium carbonate	36·29
	Ferric oxide and alumina	15·24
	Gangue (sand and clay)	2·38
		100·08

In the Capertee Valley, in fact, wherever the top strata of the Upper Marine Beds are exposed, a thin band of dolomitic limestone occurs. Its composition is shown in the following analysis, by J. C. H. Mingaye, of a sample from Green Hills, close to Glen Alice:—

No. 004-174.	Moisture at 100° C.	·70
	Combined water	3·05
	Silica (SiO_2)	8·56
	Alumina (Al_2O_3)	7·03
	Manganous oxide (MnO)	trace
	Ferrous carbonate ($FeCo_3$)	8·88
	Ferric oxide (FeO_3)	2·73
	Calcium carbonate ($CaCO_3$)	42·49
	Magnesium carbonate ($MgCO_3$)	25·49
	Potash (K_2O)	·90
	Soda (Na_2O)	·21
	Phosphoric acid (P_2O_5)	·22
	Titanic acid (TiO_2)	trace
	Sulphuric acid (SO_3)	nil
		100·26

---

[1] C. Butts states that it has been demonstrated that dolomite is equal to limestone in every respect for fluxing purposes; one Iron Smelting Company, in Alabama, using it exclusively for the manufacture of steel by the basic process.—(Bull. No. 315, U. States Geol. Survey, 1906, p. 254.)

LOCAL IRON ORES.

The iron ores smelted in the Eskbank Iron Works in 1877 were procured from Back Creek, near Blayney; at a later date from Newbridge also, The so-called "clay bands" of the local Coal Measures were also utilised. It is recorded that Campbell Mitchell opened several of these bands near Bowenfels, and disposed of a considerable quantity to the Eskbank Iron and Coal Company at nine shillings per ton.[1]

The quality of the best "clay band" is shown in Note 1 on the geological map of Bowenfels, etc. (by C. S. Wilkinson, 1875).

The following analyses of ores of the principal clay bands are by Professor Liversidge.

The lowest (No. 1), of these clay bands is situated some twelve feet above the four feet six inches or upper coal-seam (at Piper's Flat.—J.E.C.), and No. 2 and 3 clay bands are a little above the first.

No. 1.—Water, hygroscopic	1·28
Water, combined	3·54
Silica and insoluble, etc.	4·60
Sesquioxide of iron[2]	80·00
Phosphorus	·49
Sulphur	·11
Undetermined[3]	9·98
	100·00
No. 2.—Metallic iron	53·31 per cent.
No. 3.—Metallic iron	49·28 „

Note D refers to magnetic and micaceous iron ore associated with ferruginous garnet rock; about half a mile north-west of Mount Lambie; south of Portion 25, Parish Falnash, County Cook; held at that time by the Lithgow Iron Smelting Company, which proposed using it with the so-called clay band ore of the coal measures.

Of the Wallerawang iron ores, situated about three to four miles south of Portland, in Portions 150, 151, and 175, Mr. Wilkinson recorded the following in Note 7:—"Shaft sunk twenty-three feet deep (in portions 150, 151), in a mass of magnetite or magnetic oxide of iron, which at the surface has been proved to be not less than twenty-four feet in width, but the extent of the deposit has not been fully tested. The magnetite seems to occur in irregular masses rather than as a lode, and is associated with a hard siliceous garnet rock, which, in places, is highly ferruginous, containing about twenty-seven per cent. of metallic iron."[1]

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[1] Ann. Rept. Dept. Mines for 1881, p. 127.
[2] Equal to fifty-six per cent. of metallic iron.
[3] Principally manganese, alumina, lime, and magnesia.

About 12 chains north-east is another shaft sunk ten feet deep in magnetite. The following is an analysis of the magnetic iron ore by Professor Liversidge:—

Silica and insoluble portion	18·70
Metallic iron	40·89
Phosphorus	traces.
Sulphur	traces.

About fifty chains from this deposit of magnetite, in a northerly direction, is a lode of brown hematite, and about thirty-seven chains further is another deposit of brown hematite. The former can be traced on the surface for about two hundred and fifty yards, varying in width from ten to fifteen feet or more. Professor Liversidge has given the following analysis of this ore from loose ore at shaft mouth :—

Water, hygroscopic moisture	2·74
Water, combined	9·70
Silica and insoluble matter	25·33
Sesquioxide of iron[2]	54·23
Phosphorus	·27
Sulphur	·12
Undetermined[3]	7·61
	100·00

Another sample of evidently picked ore, described as goethite and massive hematite, gave :—

Water, hygroscopic	1·28
Water, combined	12·04
Silica and insoluble	12·19
Sesquioxide of iron[4]	73·60
Phosphorus	·12
Sulphur	·06
Undetermined	·71
	100·00

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[1] The Wallerawang iron deposits have since been described by J. B. Jaquet, A.R.S.M. (Mem. Geol. Survey N. S. Wales, 1901. No. 2, pp. 58, 59, 144.

[2] Equivalent to 37·84 per cent. of metallic iron.

[3] Principally manganese, alumina, lime, and magnesia.

[4] Equivalent to 51·52 per cent. of metallic iron.

COPPER SMELTING IN LITHGOW VALLEY.

The opening of collieries in Lithgow Valley, on completion of the railway across the Blue Mountains in 1869, led to the establishment of copper smelting plants at an early date. From Departmental records, it appears that the first was laid down in connection with T. Brown's Eskbank Colliery, about 1874–5. In the latter year, it was recorded that the Eskbank Copper Smelting Works were turning out fifty tons per month.

These works apparently dealt chiefly with regulus from other rented furnaces in the Cow Flat district.[1] Doubtless, ores were also purchased at the refining plant.

In 1876, copper smelting works were erected at the Vale of Clwydd Colliery, comprising two roasting and one refining furnace. A silver-lead furnace was also constructed. Copper ores were smelted from Eagle Swamp, and Armstrong's mine, near Lock's (Locksley) Platform.[2]

In 1877, the Eskbank Works turned out about six hundred and thirty tons of refined copper from Wiseman's Creek ores.[3]

Apparently, a good proportion of the regulus produced at many Western copper mines was refined at Lithgow. Most important, perhaps, was the Burraga supply, which still goes to Lithgow.

The Lloyd Copper Company, Limited, reduce Burraga ore to about thirty-nine per centum matte at the mine, and roast and refine at Lithgow, where the plant consists of three roasting and one refining furnace. Ores are purchased at the Lithgow establishment.

In the furnace-work ordinary local bricks are used in rough work; English and local fire-bricks in the furnaces; the imported for the crowns.

In 1895–6 the Great Cobar Syndicate erected a refinery at Lithgow, having secured coal land and opened a colliery; and, in 1900, added an electrolytic plant for separation of the gold and silver from the rough copper.

In August, 1906, the Syndicate's Cobar and Lithgow interests were transferred to the Great Cobar, Limited.

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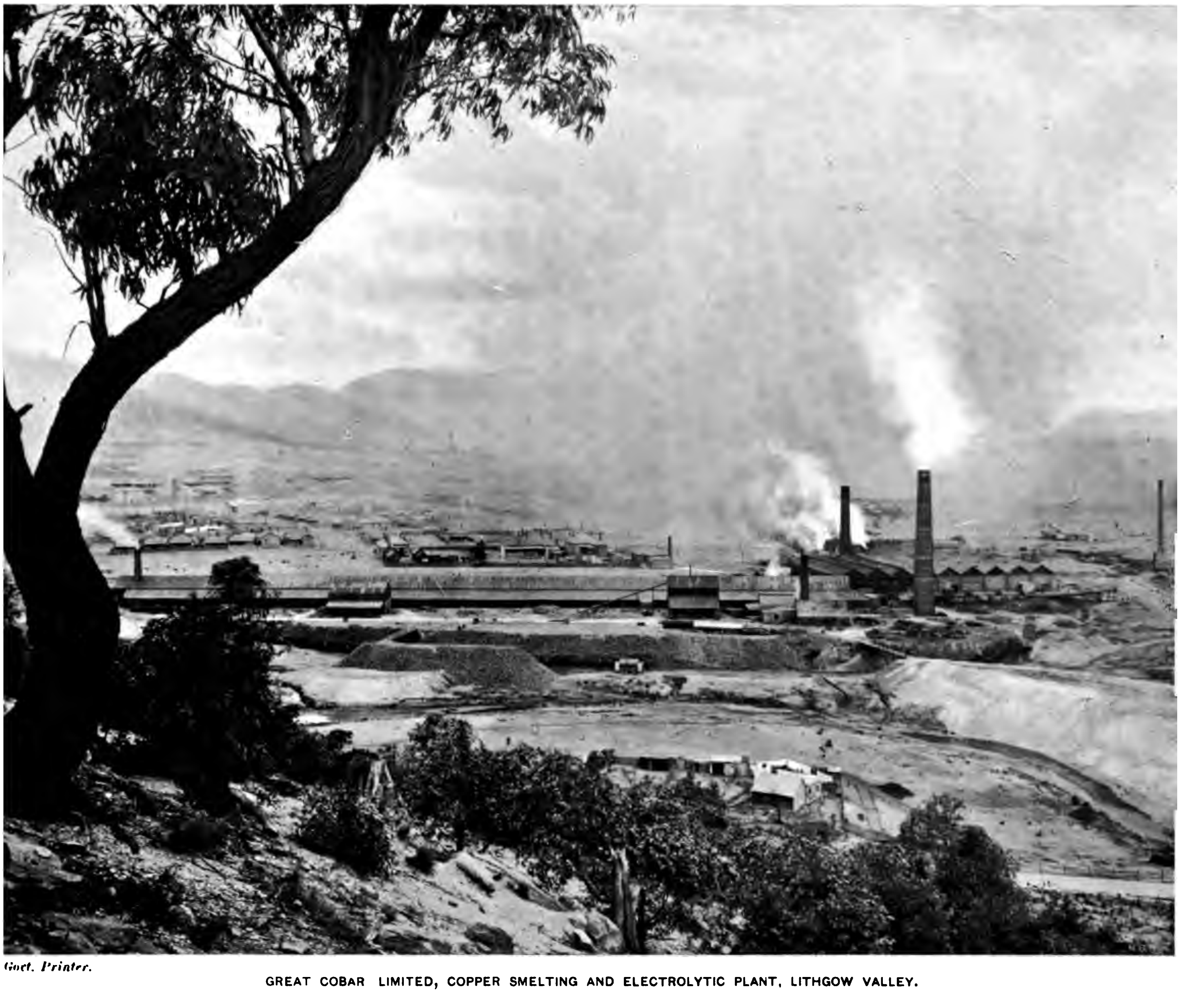
[1] Ann. Rept. Dept. Mines for 1875, pp. 59, 60

[2] *Ibid.*, 1876, p. 134.

[3] *Ibid.*, 1877, p. 179,

PLATE X



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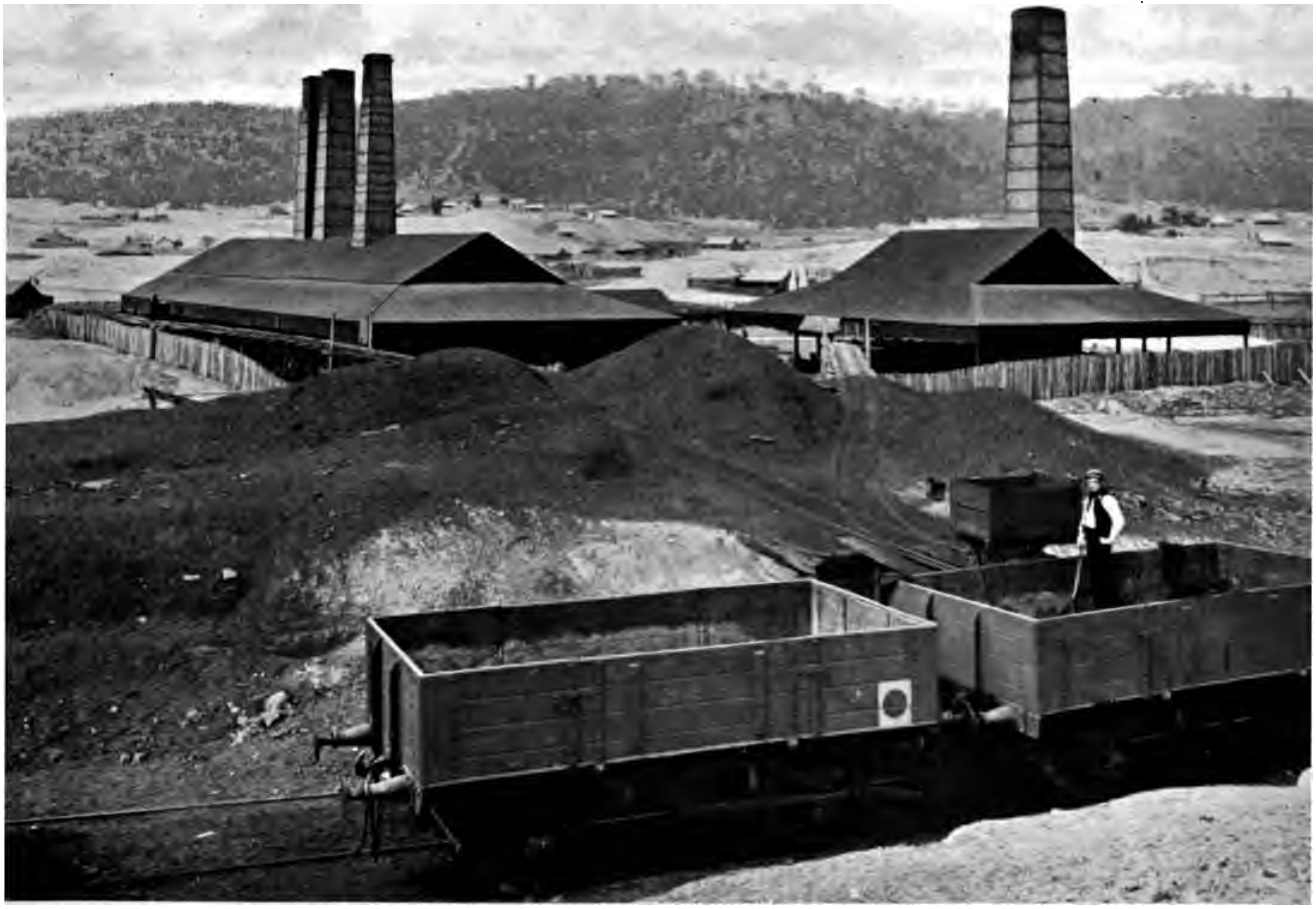
GREAT COBAR LIMITED, COPPER SMELTING AND ELECTROLYTIC PLANT, LITHGOW VALLEY.

PLATE



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The anode copper produced is refined in an electrolytic plant capable of treating about one hundred and thirty-five tons of copper in anode form each week.

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The local Coal Measures afford excellent material for ordinary bricks, drain-pipes, tiles, &c., as well as good fire-clay. The Lithgow Valley Colliery Company, Limited (which owns also the Hermitage Colliery), in 1877[1] established works for manufacture of earthenware pipes, terra cotta, ordinary, and fire-bricks, &c. This portion of the company's plant is up-to-date, four large boilers and a one hundred and fifty horse-power engine affording the necessary power.

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Ferrous oxide	7·92
Alumina[1]	21·48
Lime	·68
Magnesia	1·05
Potash	2·04
Soda	·21
	99·84

Pottery Clays.

The Lithgow Valley Colliery Company formerly manufactured drain pipes on a considerable scale, clay from near Mount Clarence Railway Station being used for the purpose. It is identical with that exposed in the road cutting at the Recreation Pavilion, Mount Piddington, the quality of which is shown in the accompanying analysis by W. A. Greig:—

No. 138.

Water at 100° C.	·31
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Silica	62·96
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Soda	·40
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Sulphur trioxide	absent.
Chlorine	trace.[2]
Chromium sesquioxide	·01
Vanadic oxide	trace.[2]
Lithia	absent.
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Specific gravity, 2·660.

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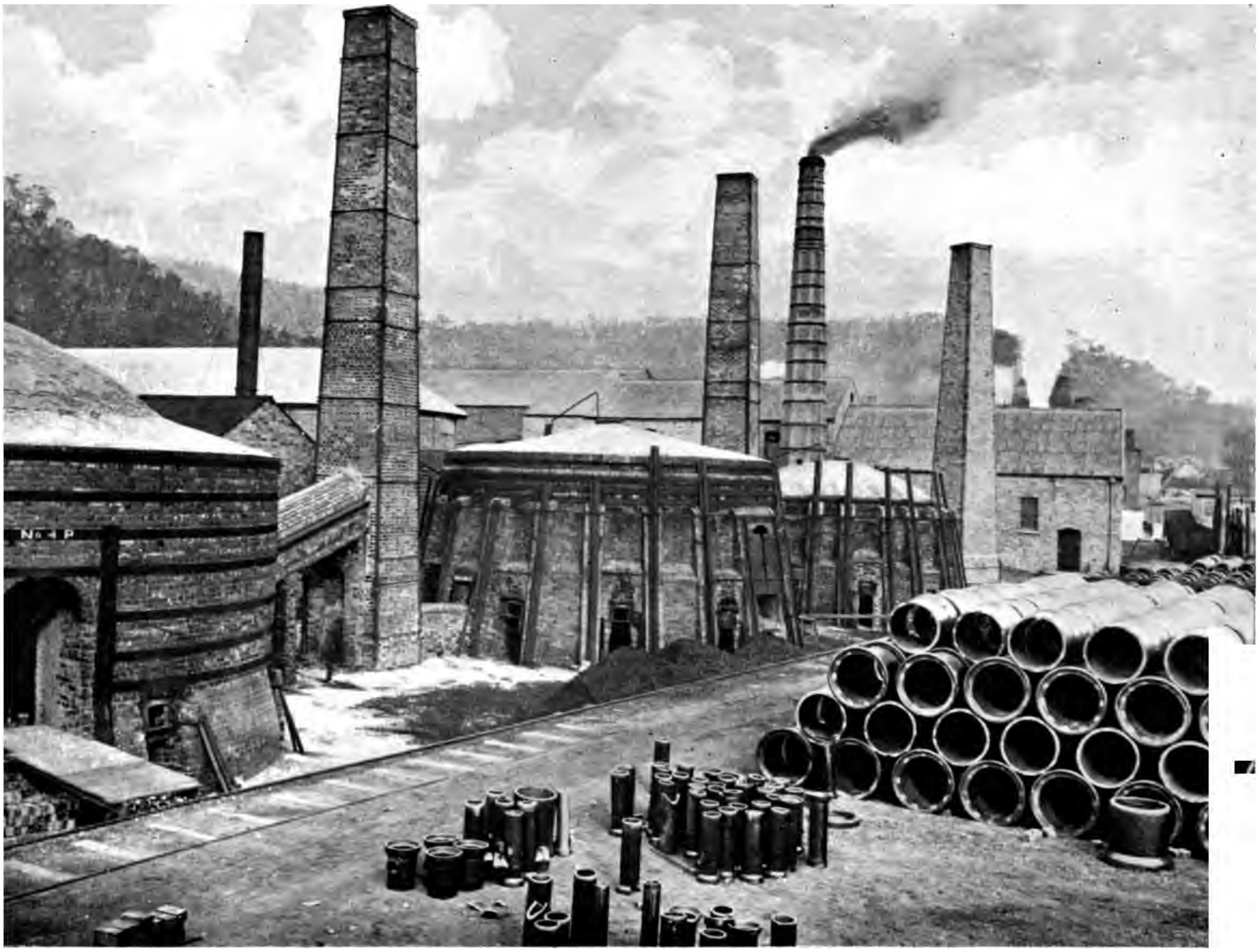
[2] Less than 0·01 per cent.



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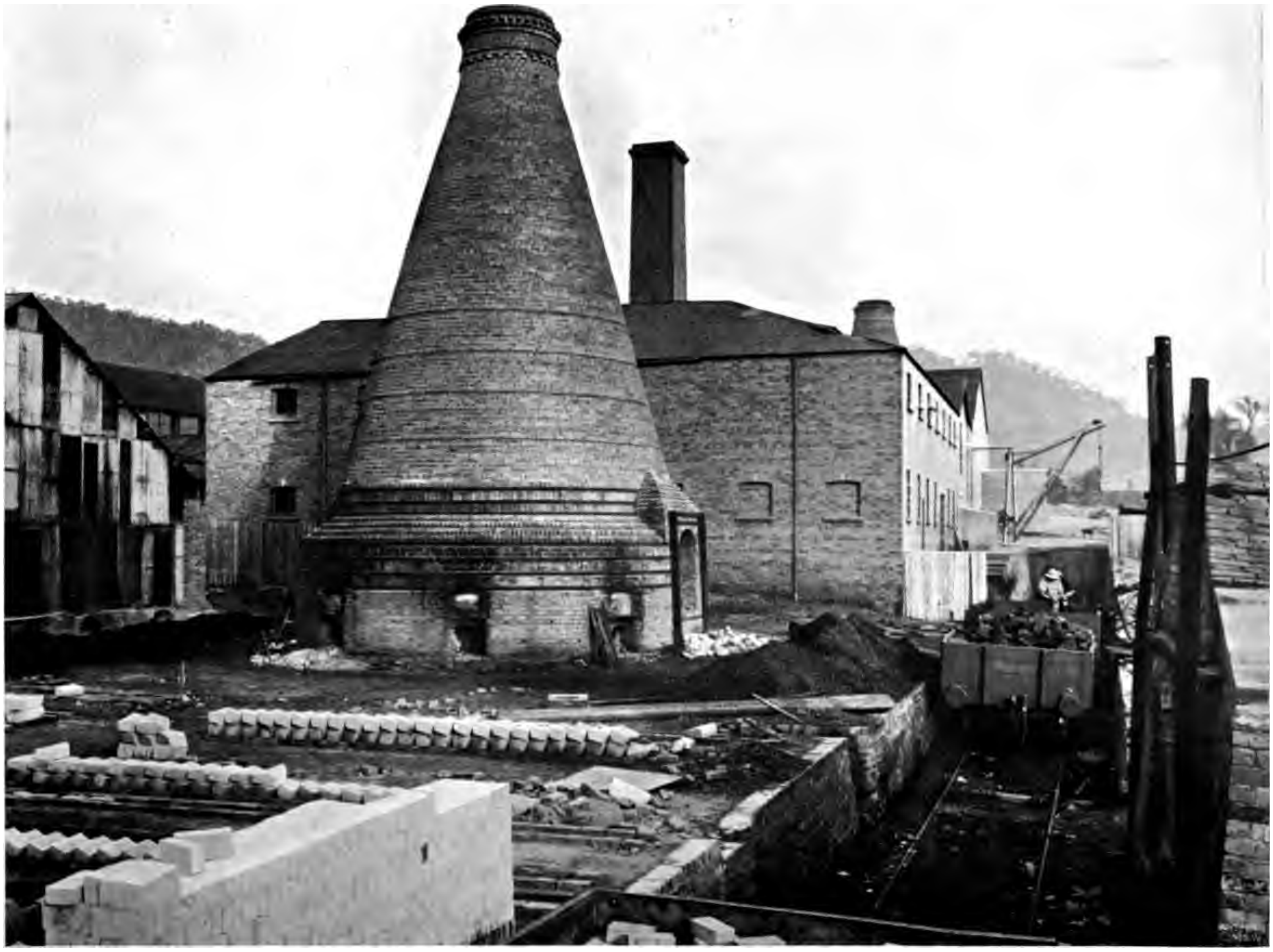
LITHGOW VALLEY COLLIERY COMPANY'S BRICK AND PIPE WORKS, LITHGOW VALLEY.



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LITHGOW VALLEY COLLIERY COMPANY'S POTTERY WORKS, LITHGOW VALLEY.

W. Sandford, Limited, use imported fire-brick in the Siemens steel furnace, and are also using them in the blast furnace in course of erection.

For the firm's ordinary furnaces, a local brick is manufactured from a mixture of local clay and crushed Devonian quartzite from Mr. Sandford's property near Marangaroo. Mortar sand for the steel furnace is obtained as loose surface material from the same locality.

For the furnace-hearth, pure sea-sand was imported from New Zealand; also from Belgium. The quality of these sands is shown in the following analyses; also of a sample from the coast at Bondi, which has since been successfully substituted for the imported:—

	Belgium. (No. 400)	New Zealand. (No. 401)	Marangaroo. (No. 402)	Bondi, N.S.W. (Nos. 06-1,053, 6170)	
	W. A. Greig.	J. C. H. Mingaye.	W. A. Greig.	W. A. Greig.	J. C. H. Mingaye.
Moisture and combined water	0·38	0·58	1·68	......	....
Silica	98·43	97·98	94·10	97·74	98·87
Alumina	0·90	0·75	3·20	1·00	·25
Ferric oxide	0·02	0·30	0·60		
Manganous oxide	absent.	....	trace.	......	....
Lime	0·05	0·01	trace.	1·26	·99
Magnesia	absent.	0·30	0·12		trace.
	99·78	99 92	99·70	100·00	100·11

It would appear from the above comparison that Bondi dune sand is equally good; in fact, it has recently been utilised in the Siemens steel furnace-hearth with satisfactory results.

Moulding Sand.

Sandford, Limited, at present use a mixture of twenty parts of ground Marangaroo quartzite with one of Mount Bopple graphite from Queensland.

At the Writer's request, Undercliff graphite, from this State, was tried with equally satisfactory results. The Queensland article, being more advantageously situated as regards cheap carriage, can be delivered at lower cost. The amount used, however, is comparatively trifling.

Mount Bopple and Undercliff graphites are identical in origin and composition, being the results of the alteration of coal-seams by granitic intrusions.

Limestone Deposits.

Portland, originally known as Limestone Flat. Sheet 11. About one mile from Portland Station on the Mudgee Railway, six miles from Wallerawang, and one hundred and ten from Sydney. Elevation, about two thousand nine hundred and ninety-two feet above sea-level. Situated in Parish Cullen Bullen, County Roxburgh.

Limestone for local building purposes was obtained in the district probably from the earliest days of settlement. Mr. J. Walker, the original grantee of the Wallerawang Estate, is reported to have obtained it from Limestone Flat over fifty years ago.

The late Mr. John Dobbie, of Hilton Park, stated that prior to 1864 lime was obtained from Brunt's Creek (probably from Portions 153 and 171, Parish Falnash, County Cook, where limestone was noted by Mr. C. S. Wilkinson, Government Geologist, on his map of the district).

In 1864 Mr. Dobbie obtained lime from the Portland deposit whilst building his residence at Hilton Park, but noticed that a little had previously been removed.

Thomas Murray selected Portions 52 and 53, Parish Cullen Bullen, County Roxburgh, at Limestone Flat, in 1863.

C. Knoblanche and C. Bate in 1879 applied for twenty acres for quarrying purposes.

The Cullen Bullen Lime and Cement Company apparently was the first company formed to work on a commercial scale; its interests were subsequently sold to the New Zealand Mines Trust Company, which formed the present Commonwealth Portland Cement Company.

In addition to the latter, the Sydney and North Sydney Lime and Cement Company and A. Gray are burning lime at Portland.

At one time a considerable amount of limestone was dispatched to Dapto and Cockle Creek Smelting Works for fluxing purposes. This trade, however, ceased when the former works closed and the latter obtained supply from the Manning River by water carriage. Iron smelting at Lithgow, and re-starting of the Australian Smelting Works at Port Kembla, will cause considerable activity in the Portland quarries.

The Portland limestone is described on the geological map of the district in Note A :—[1]

"Thick beds of coralline limestone of very pure quality, It forms a compact marble of various tints, white, cream, and dove-coloured, and sometimes with pink markings. It dresses well, and takes an excellent polish, and may be obtained in blocks of almost any required size and quality. Situated as it is, only six miles from the Wallerawang Railway Station (the Mudgee line had not then been constructed.—J.E.C.), it will be available for the iron smelting works in the district, and will afford a source of large supply for the Sydney market."

The quality of the limestone is shown in the following analysis by J. C. H. Mingaye, of a sample taken by the Writer :—

No. 2225-06.

Calcium carbonate	98·49
Magnesium carbonate	0·94
Ferric oxide and alumina	0·18
Gangue	0·48
	100·09

Phosphoric acid ((P_2O_5), 0·024 per cent.
Equal to Phosphorus (P), 0·10 „

The Brunt's Creek limestone formerly worked is described on the geological map of the district as follows :—

"Limestone conglomerate thirty-five feet thick, interbedded with brown shales. The limestone consists of very pure grey and white crystalline marble."[2]

Ben Bullen Limestone. Sheet 11. Situated about two and a quarter miles west-south-west of Ben Bullen Station, on the Mudgee Railway, with which it is connected by tram-line. About twenty miles from Wallerawang, and one hundred and twenty-one from Sydney. Elevation, about two thousand eight hundred and forty feet above sea-level.

Measured as Portions 45, 46, 47, Parish Ben Bullen, County Roxburgh.

Originally applied for in 1885-6 in five-acre leases for quarrying purposes by T. Larkin, J. Buchanan, and T. Betteson.

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[1] C. S. Wilkinson, Geol. Map. of Hartley, Bowenfels, Wallerawang, and Rydal, 1875.

[2] *Ibid.*, Note C.

About 1889 the New South Wales Lime Company secured possession, laid down a tram-line, and erected a kiln (which was little used). A considerable quantity of limestone was dispatched, presumably for flux. On ceasing operations the tram-rails were taken up.

In 1900 the three portions were leased by J. Edwards, and the tramline relaid for dispatch of flux to the Cockle Creek Smelting Works. Supply for the latter being subsequently obtained from the Manning River, near Taree, operations ceased at Ben Bullen.

The limestone occurs in diorite. The quarry face exposes about twenty-one feet of solid limestone, and a greater thickness with intercalated bands of country. Its quality is shown in the following analysis by H. P. White:—

No. 2226.

Calcium carbonate	96·76
Magnesium carbonate	2·46
Ferric oxide and alumina	0·22
Gangue (insoluble in acids)	0·50
	99·94

Phosphoric acid (P_2O_5), 0·007 per cent.
Equal to Phosphorus (P), 0·003 „

In the same locality, in Portion 48, Parish Ben Bullen, County Roxburgh, about two miles west-south-west of Ben Bullen Railway Station, a small outcrop of limestone occurs, which exhibited the following composition on partial analysis by J. C. H. Mingaye:—

No. 6152.

Calcium carbonate	89·21
Magnesium carbonate	9·11
Insoluble in acids	·80
Ferric oxide and trace of alumina	·76
	99·88

Phosphoric acid—Less than 0·01 per cent.
Trace of strontia detected.

Capertee Valley Limestone. Sheet 12. Parish Goollooinboin, County Cook.

Limestone is abundant at the "Blue Rocks" in and alongside Portion 58, and at Coco Creek, a little above the Glen Alice Road crossing. In both localities it forms high and massive cliffs. It is, moreover, intercalated in bands throughout a wide extent of country between Baal Bone Gap and Bogie River, in Parish Airly.

"Blue Rocks" consists of a massive outcrop of greyish-blue limestone, with a vertical face about three hundred feet in height, which has been caused by the undermining and solvent action of the water of Crown Swamp Creek along a joint plane. The water disappears at this point, and is not seen above ground for about three miles, where it trickles over bars of travertine.

Of the important outcrops, "Blue Rocks" is the nearest to the railway. Unfortunately, its base level lies about one thousand three hundred feet below the lowest part of the intervening Hawkesbury Sandstone plateau at Baal Bone Gap, the distance between being about three and a half miles. From the head of Crown Swamp Creek an incline tramway about thirty chains in length would be necessary to raise it to the Gap, from whence a good falling grade could be found to the railway-line.

The Gap lies about six miles east-north-east from Ben Bullen, but the available route would probably not be less than nine miles.

The quality of the limestone is shown in the following analysis by J. C. H. Mingaye of a sample from Blue Rocks:—

No. 00–3158.

Moisture at 100°C.	·150
Calcium carbonate	91·285
Magnesium carbonate	3·632
Ferric oxide and alumina	1·480
Manganese oxide	minute trace.
Lead sulphide	·725
Copper sulphide	minute trace.
Gangue (quartz)	2·520
Organic matter	trace.
	99·792

Silver—1 oz. 1 dwt. 18 grs. per ton.
Gold—A trace (a few grains per ton).

Additional samples from Blue Rocks and from a massive outcrop on Coco Creek, about a mile above the Capertee Glen–Alice Road crossing, recently submitted for analysis, yielded the following returns:—

Partial Analyses by W. A. Greig.

	No. 6780 (Coco Creek).	No. 6781 (Blue Rocks).
Moisture	·32	·42
Calcium carbonate	94·14	93·21
Ferric oxide and alumina	·66	·46
Insoluble in acids (gangue)	4·38	4·08
Magnesium carbonate, etc.	·50	1·83
	100·00	100·00

Excelsior Limestone. **Sheet 13. Parish Airly, County Roxburgh. Alongside Mudgee Railway Line, twenty-nine miles from Wallerawang and one hundred and thirty-three from Sydney. Elevation, two thousand four hundred and six feet above sea-level.**

Taken up originally by James Gallagher as a mineral conditional purchase in 1879 (M.C.P., Por. iii), who burned it for local use, but not commercially, and afterwards disposed of his interest to the Excelsior Lime Company, which subsequently sold to Messrs. Goodlet and Smith, the present owners, who use it for lime and in the manufacture of their "Rock" brand of hydraulic cement.

The following analyses, by W. A. Greig, reveal the quality of the limestone:—

No. 06–4328—Calcite.

Calcium carbonate	92·85
Ferric oxide and alumina	0·78
Gangue*	5·60
Magnesium carbonate and undetermined	0·77
	100·00

Phosphoric acid (P_2O_5), 0·066 per cent.
Equal to Phosphorus, 0·028 „

No. 4329—Compact limestone.

Calcium carbonate	97·68
Ferric oxide and alumina	0·90
Gangue*	0·74
Magnesium carbonate and undetermined	0·68
	100·00

Phosphoric acid (P_2O_5), 0·046 per cent.
Equal to Phosphorus, 0·020 „

Close to Brogan's Creek and McDonald's Hole, on the Mudgee Railway, limestone occurs intercalated in Devonian Sedimentaries. A note to this effect is placed on Sheet 13. In places the outcrops are massive, as in Mineral Lease 1, Parish Airly, County Roxburgh, which has been taken up for quarrying purposes, the lease of eighty acres being within about one and three-quarter miles from the nearest point of the railway line.

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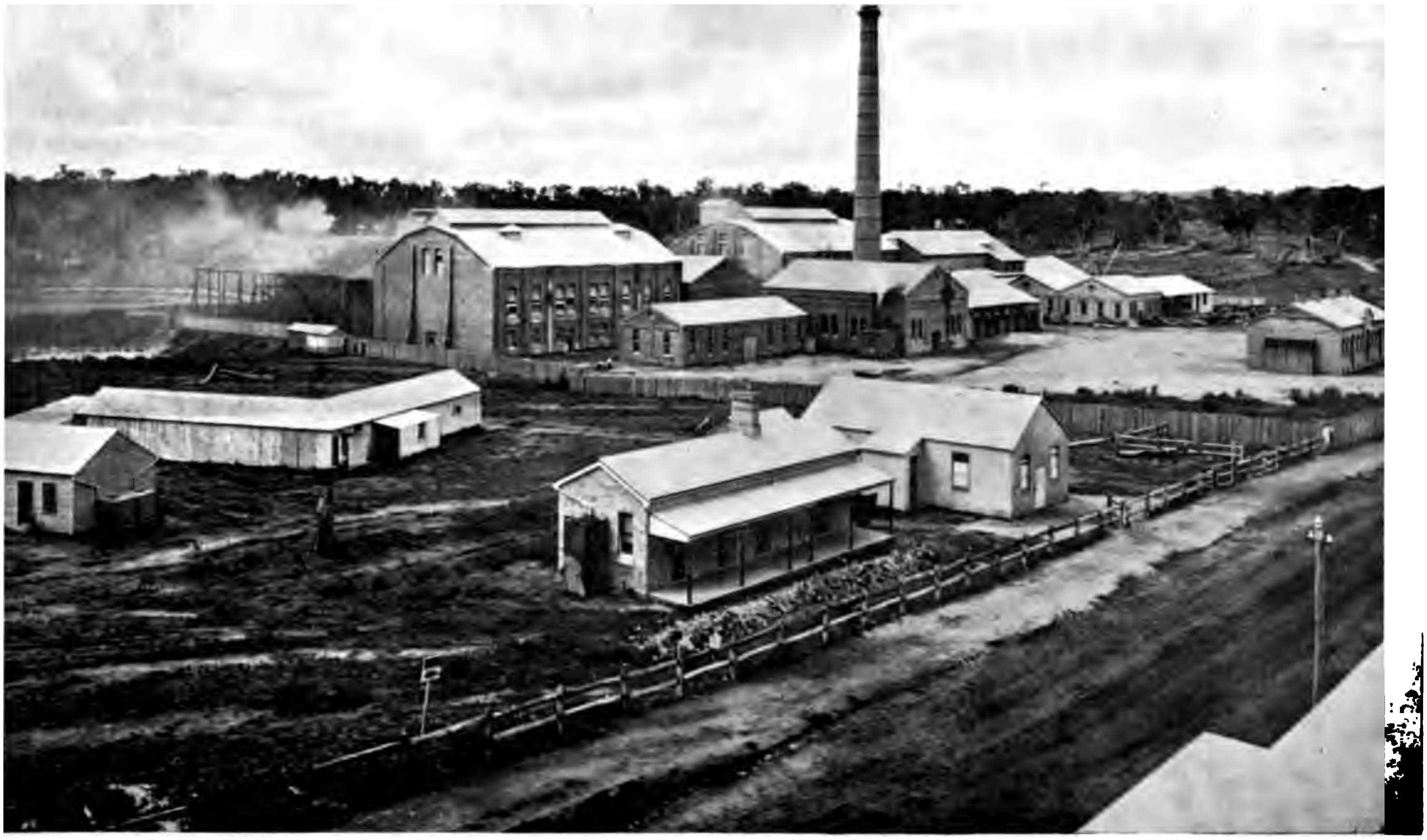
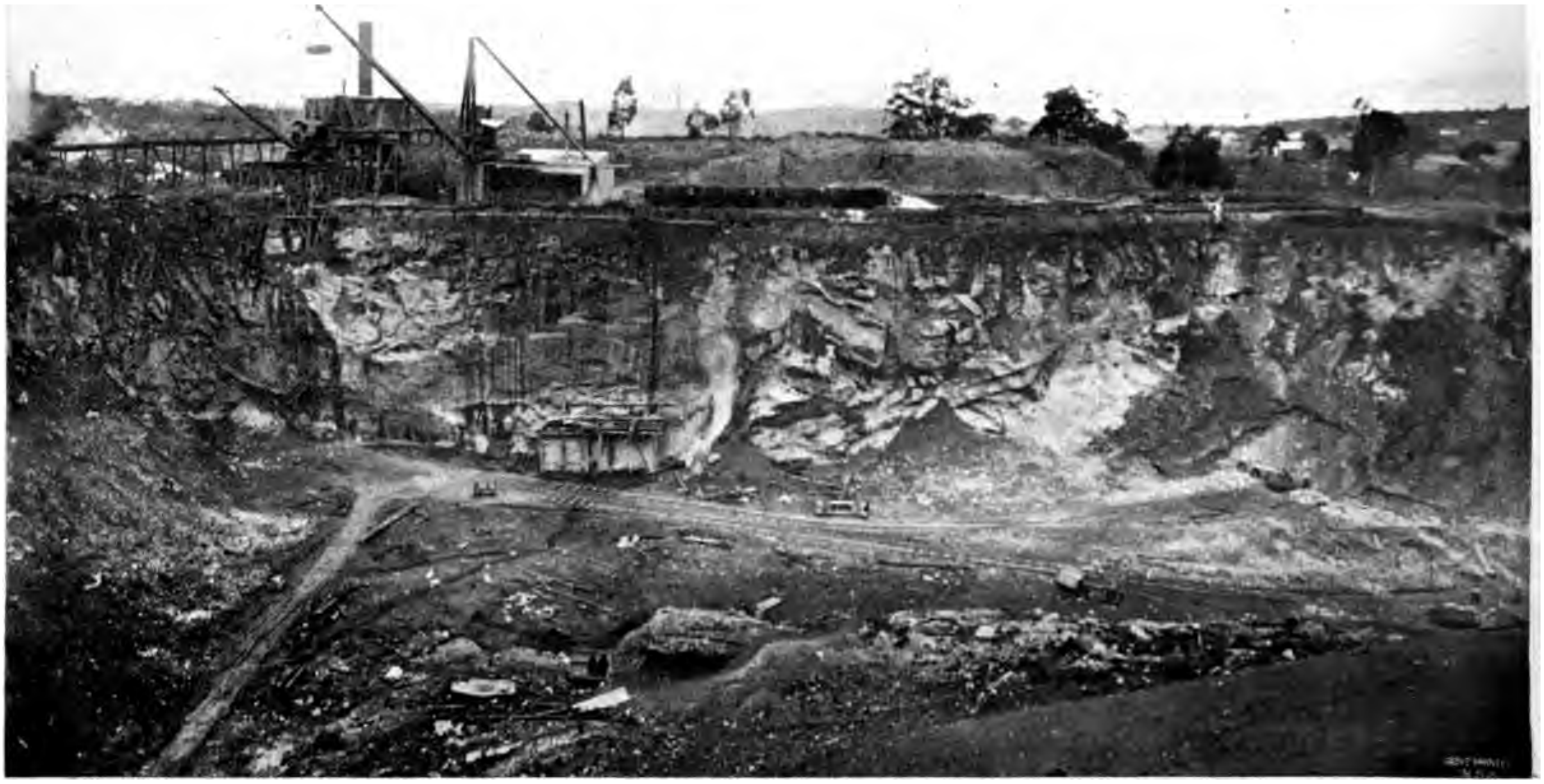
* Gangue consists of nearly clean silica.

Plate XXXIII.



COMMONWEALTH PORTLAND CEMENT WORKS PORTLAND.

PLATE XXXIV.



COMMONWEALTH PORTLAND CEMENT COMPANY'S LIMESTONE QUARRY, PORTLAND.

A sample from an outcrop about five chains east of south-east corner of Portion 1, Parish Clandulla, County Roxburgh, yielded the following results:—

Calcium carbonate	91·96
Magnesium carbonate	7·09
Ferric oxide and alumina	·46
Gangue	·76
	100·27

Commonwealth Portland Cement Works, Portland. Sheet 11. Situated on the Mudgee branch of the Great Western Railway, one hundred and eleven miles from Sydney, at an elevation of nearly three thousand feet above sea-level.

The scope of the works may be judged from the following views kindly supplied by Dr. A. Scheidel, managing director of the Commonwealth Portland Cement Company (Limited). The equipment is equal to an output of one hundred and fifty tons of cement per day.

All branches of the works and the associated Ivanhoe Colliery are connected with each other, and with the Government Railway at Portland Station, by standard gauge lines

The town arising around the works has a population of about one thousand inhabitants.

The most important feature in connection with this extensive enterprise is the occurrence, with one minor exception, of all the requisite raw materials and coal, in close proximity on the same property, to produce the company's "Union" Portland cement, which has passed all standard tests, and is extensively used in the Commonwealth, both in Government and private undertakings.

The one exception is the small percentage of gypsum necessary to prevent too rapid setting of the cement; the supply being at present obtained from South Australia, where its occurrence on the seaboard ensures delivery at Portland at comparatively low cost.

In grinding the materials, both before and after roasting, fina comminution is attained in flint ball mills. The well-known "flints" of the chalk beds of the London and Parisian Basin, used for this purpose, have not as yet been found in Australia. Local experience, however, has discovered a fairly effective accessory in the hard quartz-felsite pebbles from the ancient Lapstone River gravel worked by the Emu and Prospect Metal Company, the practice being to use equal proportions of each.

The Commonwealth Company also prepares building lime in "flare" kilns. Limestone flux was also in considerable demand whilst the Dapto Smelting Works were in operation, and before those of Cockle Creek procured supplies from the Manning River.

It is interesting to note that the small reverberatory hearths on which the gold and silver slimes from the electrolytic vats are melted at the Great Cobar (Limited) works at Lithgow are made of Commonwealth Portland cement, which is found to answer the purpose admirably.

GOLD.

The auriferous nature of portions of the Upper Marine conglomerates has been fully dealt with in the Memoir on Kerosene Shale Deposits by the Author,[1] to which the reader is referred.

Sufficient attention has not been given to this source of gold; hence special attention is directed to the deeper valleys in the Blue Mountains in which beds of Upper Marine age have been largely exposed and deeply eroded by denudation.

"Though, from experience gained at Tallawang, Clough's Valley, and Tucklan, it is evident that the gold contents are very patchy and variable, yet it is equally demonstrated that the gold is not restricted to any particular locality, but is widely distributed throughout the region now or formerly occupied by littoral deposits of the Upper Marine conglomerates. It is probable that embouchures of contemporaneous streams may contain auriferous deposits somewhat approaching the nature of leads, wherein the heaviest of the gold remains; but the transporting action of waves, tides, and coastal currents would be certain to distribute the lighter gold particles along the coast in somewhat similar manner to that pertaining to the auriferous beach sands of our northern coasts, and those of New Zealand.

"Under the mode of deposition suggested, it is reasonable to anticipate *patches* of payable conglomerate *in situ*; but successful mining will be confined chiefly to areas of recent concentration. Hence attention is herein

---

[1] Mem. Geol. Survey N. S. Wales, Geol. 3, 1903, pp. 129-133.

specifically directed to the Blue Mountain valleys, and particularly to the present drainage channels through which such vast quantities of the conglomerates have been naturally ground-sluiced and their valuable contents concentrated. Gold-miners have naturally fought shy of the coal regions in prosecuting their labours; but once they recognise that many of the rich gold leads and channels falling westward from the margin of the coal areas have derived their gold from the conglomerates of the latter, they will, or should, turn their attention to the upper parts of those valleys which drain eastward through the Coal Measures of the Blue Mountains."

Gold has been won from Nuggety and Sandy's Gullies and Blackfellows' Ring, in the Capertee Valley, Sheet 13; and it is more than likely that the principal streams and their tributaries, forming the drainage system of that valley, will be found to contain payable patches of reconcentrated gold, particularly in proximity to "bars" and "crevices" in the stream channels.

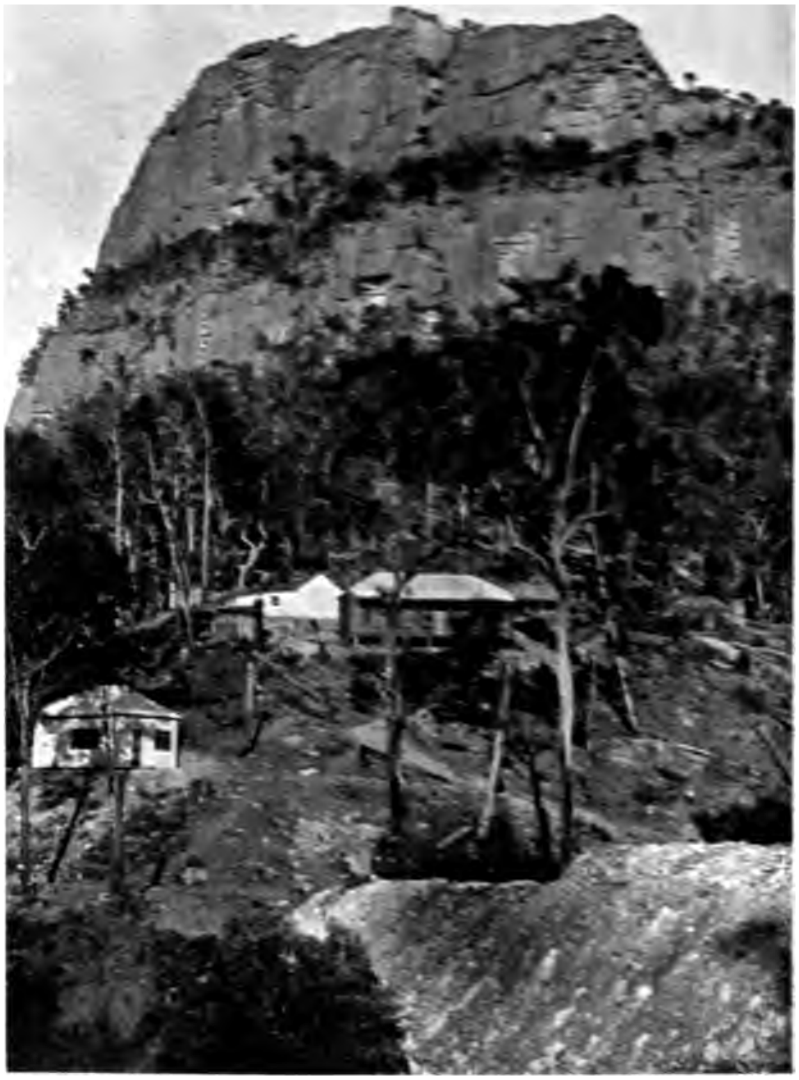
In the Valley of the Cox, gold is also obtainable where the Upper Marine conglomerates have been extensively denuded and dissected.

At the "Knob," near Ben Bullen, gold has been found in very flat-lying joints in Devonian Sedimentaries; but from their thinness and mode of occurrence, are hardly likely to prove payable at a depth.

TIN.

A little tin oxide has been found at Meadow Flat—Sheet 11—but not in commercial quantities.

PLATE XXXVI.



NEWNES, WOLGAN RIVER (SHOWING PORTION OF TIP FROM No. 1 TUNNEL IN FOREGROUND).

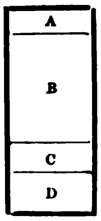
APPENDIX.

The following particulars of recent developments in the Capertee and Wolgan Kerosene Shale Tunnels, and in the Wolgan Colliery, have been supplied by the Commonwealth Oil Corporation through its analyst Mr. H. L. Jene, Associate, Adelaide School of Mines, under date November 6th, 1907 :—

The tunnel in M.P. 1, Newnes North, Capertee Valley, has been extended over four thousand feet in the Kerosene Shale Seam, which maintained an average thickness of over fifty inches, and uniform quality throughout. Usually about forty inches average sixty-five per cent. of volatile matter,[1] or one hundred and thirty-three gallons of crude oil per ton.

About six inches from the bottom of the seam a band of "splinty" shale occurs, which averages forty-five per cent. of volatile matter, or eighty gallons of crude oil per ton.

The constitution of the seam is illustrated in the following section and analyses, at three thousand one hundred and forty feet in the tunnel :—

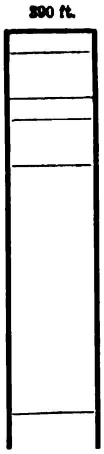


ft.	in.		Volatile matter. Per cent. [2]	Gallons Crude Oil. Per ton.
0	5½	Tops	35·8	68·6
2	9	Export shale	64·7	134·4
0	6	Splinty shale	44·0	79·8
0	8	Export shale	69·9	147·0
4	4½			

Stratigraphical sequence and association is revealed in the following sections :—

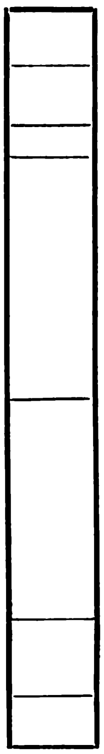
At 390 feet, 837 feet, 1,245 feet, and 1,521 feet in Main Capertee Tunnel, M.P. 1.

390 ft.



ft.	in.	
0	4½	Coal.
0	8	Stony shale.
0	5½	Fireclay.
0	9	White clay holing.
4	4½	Kerosene shale. 63 % Volatile hydrocarbons or 133 gallons crude oil.

837 ft.



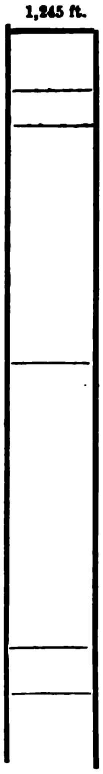
ft.	in.	
1	0	Clay shale.
0	7	White clay holing.
4	2	Kerosene shale (high grade).
3	10	Sandstone.
1	5	Coarse shale.
0	10	Coal.

---

[1] Including about 0·5 per cent. of hygroscopic moisture.

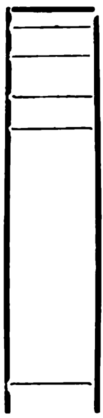
[2] Volatile matter in each case includes hygroscopic moisture, which is usually under 0·5 per cent.

1,245 ft.



ft.	in.	
1	1	Clay shale.
0	7	White clay holing.
4	2	Kerosene shale (high grade).
5	0	Sandston
0	10	Coarse shale.
		Coal.

1,521 ft.

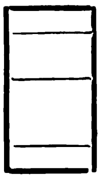


ft.	in.	
0	3½	Stony coal.
0	6½	Coarse shale (30 gallons crude oil per ton.
0	8	Clay shale.
0	7½	White clay holing.
4	5	Kerosene shale (high grade).

No. 1 Tunnel, Wolgan Valley, has been extended about two thousand feet in the Kerosene Shale Seam, which here ranges from 15 to 20 inches in thickness, of an average grade of about eighty gallons of crude oil per ton. One foot of it runs to about fifty-eight per cent. of volatile matters, or one hundred and eighteen gallons crude oil.

The No. 2 or Main Tunnel, which is eventually to connect with the main Capertee tunnel, in M.P. 1, a distance of about twenty-one thousand feet, is in about one thousand one hundred feet in an average thickness of two feet of Kerosene Shale, of an average value of fifty-five per cent. of volatile matters, or one hundred and fourteen gallons of crude oil. An eighteen-inch cut averages sixty per cent. of volatile, or one hundred and twenty-two gallons crude oil per ton.

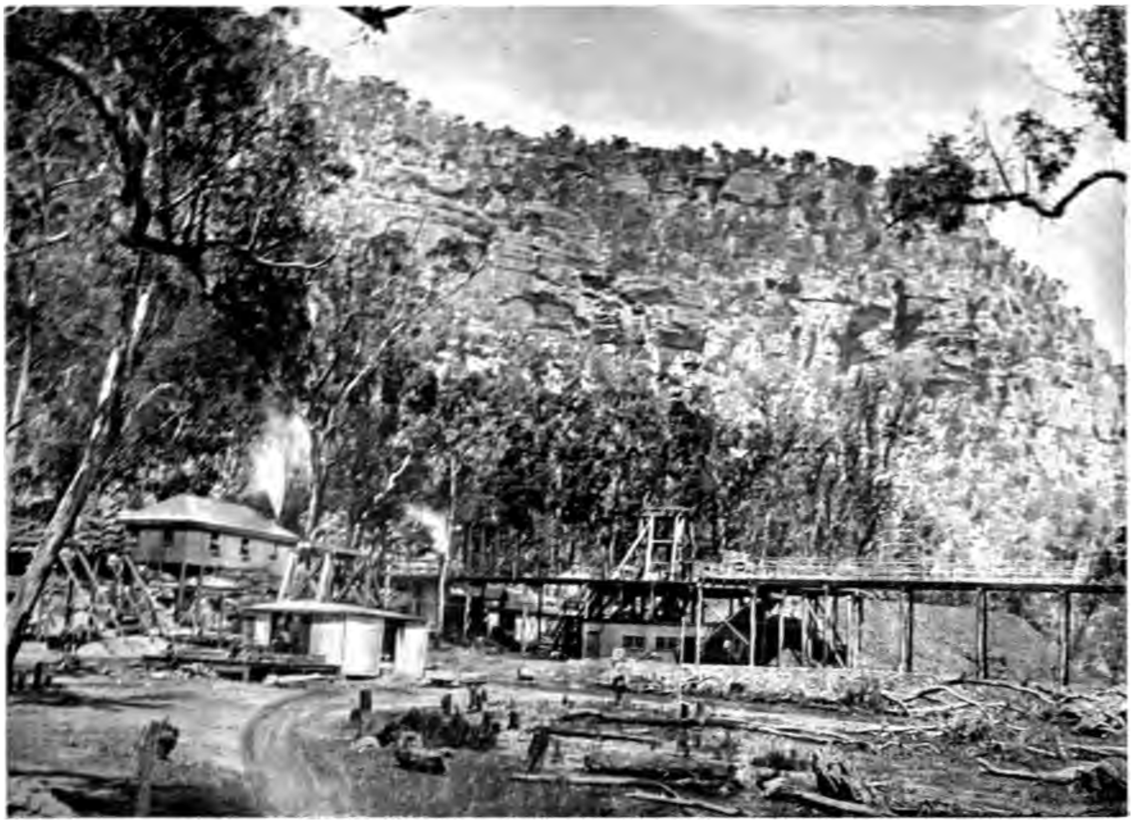
The following section at nine hundred and ninety feet in this tunnel illustrates the constitution of the seam :—



ft.	in.		Volatiles per cent.	Gallons Oil per ton.
0	4	Tops	43·8	86·8
0	7½		57·2	117·6
0	10		68·6	137·2
0	4	Stony bottoms	17·8	35·0

The dip of the kerosene shale seam between the Wolgan outcrop and M.P. 1 tunnel in Capertee Valley, based on the levels of each, amounts to about 1 in 35 towards the latter.

PLATE XXXVII.



WOLGAN COLLIERY, NEWNES, WOLGAN RIVER.

Four Beehive ovens of a capacity of six and a half tons each per charge, have been constructed at the colliery for practical test of the coking qualities of the top two feet three inches of the Wolgan Seam, the coal being used without previous washing. The result being production of an excellent hard coke containing an average of under nine per cent of ash.

The output being about sixty per cent of marketable coke, and 2·9 per cent of fines.

The following analysis of a sample taken from a sixty-ton lot of the coke is furnished by Mr. Jene :—

Volatile matter	1·5	100·
Fixed carbon	89·7	
Ash	8·8	
Sulphur	0·58	

The ash from this sample yielded :—

Silica SiO_2	60·6
Alumina (Al_2O_3)	28·2
Ferric oxide (Fe_2O_3)	6·8
Calcium (CaO)	2·5
Magnesia (MgO)	0·72
Sulphur trioxide (SO_3)	0·085
Phosphoric acid P_2O_5)	0·911*
Undetermined	0·184
	100·000

* Equal to 0·398 % phosphorus.

The coke from which the ash was obtained gave the following calculated results :— Phosphoric acid (P_2O_5) 0·122 per cent. : equal to phosphorus 0·053 per cent.

A full section of coke from one of the ovens, represented by a column two feet ten inches in height was subjected to divisional test with the following results :—

Section of Coke.	Volatile Hydro-carbons.	Fixed Carbon.	Hygro-scopic Mixture.	Ash.	Total.
ft. in.					
0 4 Tops	1·33	89·42	0·85	8·40	100·00
2 3 Middles	1·40	89·50	0·90	8·20	100·00
0 3 Bottoms	5·60	82·40	3·80	8·20	100·00
2 10					

"Dirty" Seam, Wolgan Valley—

Section and analysis of outcrop of upper portion near Wolgan Railway Line :—

Débris.
Coal 1 ft. 3 in.
Band 0 ft. 1 in.
Coal 2 ft. 9 in.*
Clay shales.

Analysis No. 07–7,622 of lower 3 ft. 5 in., exclusive of band.

Hygroscopie moisture	13·52
Volatile hydrocarbons	25·33
Fixed carbons	43·75
Ash	17·40
	100·00

* Two thin bands (not persistent) in this portion.

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